

Teacher's Resource Guide



Welcome to



THIS GUIDE IS AN EDUCATOR'S COMPANION TO MOLECULARIUM™
THE EXCITING, NEW, ANIMATED DOME EXPERIENCE .

- ABOUT THE SHOW -

Molecularium™- Riding Snowflakes

*is a magical, musical adventure into the world of ATOMS and MOLECULES! This Digital-Dome experience takes you on a journey with OXY, HYDRO and HYDRA, an amazing cast of atoms, aboard the most fantastic ship in the Universe: the **MOLECULARIUM**. It is the result of an unprecedented collaboration between scientists and artists, educators and entertainers. **Molecularium** brings kids on a musical cartoon adventure into a NANOSCALE UNIVERSE created from accurate molecular simulations. They learn about the 3 states of matter as they travel into a cloud, watch a snowflake form, and count the number of water molecules in a raindrop.*

- ABOUT THIS GUIDE -

The Molecularium Teacher's Resource Guide is made for elementary educators teaching their students about STATES of MATTER, ATOMS and MOLECULES. It is not necessary to see the show to put this guide to good use, but teachers taking their classes to see the show will find it especially useful.

HOW DOES IT FIT WITH YOUR CURRICULUM REQUIREMENTS?

THIS TEACHER'S GUIDE ADDRESSES THE FOLLOWING NATIONAL SCIENCE EDUCATION STANDARDS

National Content Standard (K-4)	Key Idea
Standard A-Science as Inquiry	<ul style="list-style-type: none">• Abilities necessary to do scientific inquiry• Understanding about scientific inquiry
Standard B- Physical Science	<ul style="list-style-type: none">• Properties of objects and materials• Position and motion of objects• Light, heat, electricity, and magnetism
Standard C- Life Science	<ul style="list-style-type: none">• The characteristics of organisms
Standard D- Earth and Space Science	<ul style="list-style-type: none">• Properties of earth materials
Standard E-Science and Technology	<ul style="list-style-type: none">• Abilities of technological design• Understanding about science and technology• Abilities to distinguish between natural objects and objects made by humans



- THE GOAL OF THIS GUIDE -

The goal of this guide is to help you have a great time with your students as you explore the **nanoscale** universe of atoms and molecules. These hands-on lessons are aimed at showing more than telling. Experience is the best teacher, so these lessons aim to make experiencing ideas fun. New words are learned as new discoveries are made through experimentation and demonstration. We strongly encourage you to **HAVE FUN** with **OXY** and all of her friends!

- Kurt Przybilla

Writer/Producer - Molecularium™



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LESSON ONE: *Matter, Matter, Everywhere!*

Objectives:

- Students will be able to name the three STATES of MATTER.
- Students will be able to identify solids, liquids and gases.
- Students will be able to describe different properties of the different STATES of MATTER.
- Students will understand that temperature and STATES of MATTER are related.

Introduction:

1. Tell everyone that today they are going to become scientists. Ask them what they think a scientist does. Have them complete the sentence, “A scientist...”
2. Explain that one of the most important jobs of a scientist is to observe and classify. Explain that “observe” means to watch or look at something very carefully and “classify” means to put things into groups (classes).
3. Give or elicit examples of classification. (i.e. Clothing can be grouped into tops, bottoms, shoes etc...) Ask students to give examples of each group. When they get the idea, have them decide how to classify another category such as food or sports. It is useful to write the categories on the board so that they can see the groupings.
4. Write “UNIVERSE” on the board. Ask students what this word means to them. Discuss that this word is used to describe everything; all that is. Explain that scientists have divided the Universe into main two classes. Write “MATTER” and “ENERGY” on the board below.
5. Explain that “MATTER” is the word that scientists use for the “stuff” that all things are made of and that “ENERGY” is the word they use to describe what moves that stuff.
6. Explain that they are going to focus on studying MATTER, the stuff things are made of. Explain that scientists have classified MATTER into three main categories called STATES (or PHASES). They are going to observe some matter and classify it into the different STATES.

ACTIVITY: Observing THREE STATES of MATTER

Materials:

- Ziplock bags
- Rocks (or any other solid you wish, i.e. a ball, a wood block, a pencil)
- Water with food coloring

Note: The following activity can be done as a guided activity for younger ages or as a small group activity for older ages who can use the handout included in the appendix to investigate on their own. The procedure described is for the guided activity for younger ages. If done in small groups, you can rotate bags to save on material preparation.

Procedure:

1. Prepare Ziplock bags. In one bag have a rock, fill another full of colored liquid and inflate the third full of air. Put them in a paper bag so the students can't see them, heightening their curiosity as you take each one out.
2. Take out the bag with the rock and have students describe what is in the bag. Have them describe its shape, weight and hardness. Ask if it takes up space. Take it out of the bag and let

students examine it. Ask if its shape changes. Put it in the cup. Ask if its shape changed to fit the cup. Does it have weight? Hold it above the table and ask what will happen if you drop it. Will it go through the table? Demonstrate that it does not and explain that it and the table are both SOLIDS. Write the word SOLID on the board under MATTER.

3. Take out the bag of LIQUID and have the students describe it. Again have them describe its shape, weight and hardness. Ask if it takes up space. Ask what will happen if you open the bag and tip it. Open the bag and pour some into the cup and ask if the shape has changed. Ask what will happen if you pour a little on the table. Do this and ask how the shape has changed. Note how it spreads out in all directions (if the table is level). Introduce the term LIQUID and write it on the board.
4. Take out the bag of air and have the students describe it. Since GASES are usually invisible, students may at first think that there is nothing in the bag and some demonstration is useful before having them describe it. Show them there is something in the bag keeping the sides of the bag from touching each other. Pass around the bag and let them feel it. Ask if anyone knows what is in the bag. If no one does, ask what is in a balloon. Discuss that the bag is full of air. Ask if air takes up space. Ask what will happen if you open the bag. Do it and let most of the air escape. Ask them what happened to it. Ask if it changed its shape. Explain that air is moving all around us but that it is invisible. Talk about how we breathe it all the time. Have everyone take a deep breath and blow on their hand to feel the air. Ask what will happen if you blow into the bag. Inflate the bag and show them that you can fill the bag with it. Introduce the term GAS and write it on the board.

Discussion:

Summarize and review their observations by talking about and listing the properties of these THREE STATES OF MATTER on the board.

MATTER

SOLIDS

- TAKE UP SPACE
- HAVE A FIXED SHAPE
- CAN'T PASS THROUGH IT
- DON'T FLOW
- HAVE WEIGHT

LIQUIDS

- TAKE UP SPACE
- CHANGE SHAPE TO FIT CONTAINER
- CAN PASS THROUGH IT
- FLOW
- HAVE WEIGHT

GASES

- TAKE UP SPACE
- CHANGE SHAPE TO FILL SPACE
- CAN PASS THROUGH IT
- INVISIBLE (USUALLY)
- HAVE WEIGHT

Note that MATTER always takes up space and has weight. The amount of space MATTER takes up is called VOLUME. Scientists use the word MASS to talk about how much MATTER there is in something. Scientists weigh things to find out how much MASS different things have. The more something weighs, the more MASS it has. MASS is related to WEIGHT more than SIZE (VOLUME). Of the three things observed, the AIR was the largest (had the most VOLUME), and also the lightest (had the least MASS). Write this on the board: **All MATTER has MASS and VOLUME.** These are two PROPERTIES of MATTER.

DEMONSTRATION: *Air takes up space*

Materials:

- a big clear bowl or container full of water (an aquarium is perfect)
- a clear glass tumbler or beaker
- a piece of paper
- a Styrofoam packaging noodle (any small piece of Styrofoam will do).

Procedure:

[Note: You can review the STATES of MATTER throughout this demonstration by asking what is the STATE of each material as you introduce it.]

1. Hold up the empty glass and ask what is in it. (Give high praise to anyone that says air and tell them you are going to prove it for them right now.)
2. Crumple up a piece of paper and stuff it in the bottom of the glass so that it doesn't fall out when you turn it upside down.
3. Ask what will happen if you push the glass straight down into the bowl of water. Ask if the paper will get wet.
4. Push the glass straight down into the water. Allow everyone to have a look.
5. Take it out of the water and have someone remove the paper.
6. Ask why the water didn't go up into the glass.
7. Float a Styrofoam packaging noodle on the surface of the water. Put the glass over the noodle and push it down to the bottom. Have everyone observe what happens.

Discussion:

Talk about what they observed. Ask why the paper didn't get wet and the noodle was pushed down. Make clear that the cup was not empty but full of air. Talk about how they could see that the air takes up space and prevented the water from filling the cup. What is a word for the amount of space? You may wish to explain and demonstrate that you trapped the air in the cup by pushing straight down. If you pushed it in at an angle, the air would escape and water would rush in, pushing most of the air out.

ACTIVITY: *Transforming Matter***Material: (for each pair)**

- A sealed plastic bag
- An ice cube
- A watch or clock for timing
- Ice trays
- A cooler (optional)
- A clock or watch that displays seconds

Procedure:

1. Show and tell the students that you took water from the faucet and put it into the ice tray. Ask what STATE OF MATTER the water was in when it came out of the faucet. Tell them that you left the water in the freezer overnight. Ask what happened to the water. Show the students the ice cube tray that was left in the freezer overnight.
2. Tell the students that today they are going to design a method that will melt their ice cube (change from a solid to a liquid) in the shortest time possible.
3. With their partner they need to agree on a method that they want to try in class. Once they come up with a method they should write their method on the top of the record sheet. Show and tell the students that each partnership will get a sealed plastic bag with an ice cube in it. There is one rule; they are not to remove the ice cube from the bag. Each pair's plan must be

okayed before they receive their bag. Of course, you should not okay an unsafe method. When conducting experiments it is always important to follow safety procedures.

4. Tell students to record the starting time. To be scientific, it is best to keep the bags of ice in a cooler until it is given to each pair and record the time that it is given to them.
5. They should pay special attention as they apply their method and record the moment when all of their ice is melted. You can require them to bring it to you to verify their melt time.
6. Have them calculate how long it took to melt the cube with their method.

Discussion:

Bring the students together as a whole group to discuss their observations and to compare their melting process and times. Make a chart recording the various methods and final times on the board. Discuss why different methods melted the ice faster than others.

Expand:

Tell the students that they will conduct another experiment. Put the water from one of the bags into an uncovered Petri dish or cup. Ask what they think will happen to the water. Keep another bag sealed and have students predict what will happen to the water in the bag. Record the start times for both and leave them. Check them throughout the day and the next. By the next day, most if not all of the water in the Petri dish will have EVAPORATED. Ask what happened to the water in the dish. Ask if anyone has ever heard of the ATMOSPHERE. Discuss their ideas and explain that the ATMOSPHERE is the layer of GASES that surrounds a planet. What is a SPHERE? Earth's ATMOSPHERE has many GASES and a lot of water. Discuss the WATER CYCLE taking place in the Earth's ATMOSPHERE. Warm water on the surface of the Earth EVAPORATES, going from LIQUID to GAS and becoming part of the ATMOSPHERE. Warm air rises; and it holds more WATER VAPOR than cold air. As warm air rises, it cools and the WATER VAPOR in the air CONDENSES changing back to a LIQUID (or sometimes SOLID ICE CRYSTALS if it is cold enough). Discuss rain, snow and clouds.

Discuss the water in the sealed bag. Why didn't it evaporate? Discuss how the air inside the bag is a closed system, so it doesn't EVAPORATE into the ATMOSPHERE.

DEMONSTRATION: *Three States of Water*

Material:

- Hot plate or other source of heat
- A pyrex beaker or container
- Ice Cubes
- A piece of black (dark) paper

Procedure:

1. Put the ice in the container. Ask what STATE of MATTER the ice is in.
2. Put it on the hot plate and turn it on. Have the students predict what will happen.
3. When all the ice has melted, ask what STATE of MATTER the water is in.
4. Ask what would happen if you put the container in the freezer now.
5. Continue to heat it. Put a piece of black paper (or dark background) behind the beaker so that the steam is more visible.
6. Have the students predict what will happen.

7. While it EVAPORATES, ask what is happening to the water. Point out that the hot air and WATER VAPOR are rising.
8. Demonstrate that you can turn it back to liquid by holding a glass of ice over the beaker causing the vapor to CONDENSE on the outside of the cold glass. Ask if anyone has noticed this happen on a hot summer day.

Discussion:

Talk about how the water has just gone through three STATES of MATTER. Discuss how changing the TEMPERATURE and the STATE of MATTER are related. Explain that HEAT is a kind of ENERGY. Draw a Celsius thermometer on the board. Have the students organize the STATES of MATTER according to their temperature by tracing the transformation of the ice cube into water and then steam, teaching and reinforcing the following vocabulary along the way: SOLID, LIQUID, GAS, STATES OF MATTER, FREEZING POINT, MELTING POINT, BOILING POINT, CONDENSATION and EVAPORATION. Discuss how TEMPERATURE and STATE OF MATTER are very related. Tell them that in the next lesson they will explore why.

RESOURCES FROM THE MOLECULARIUM:**SONG: *Three States of Matter***

Using songs from the show is a very effective and fun way to reinforce each lesson. Duplicable lyric sheets can be found in the appendix of this resource guide, and all of the music can be downloaded at www.molecularium.com/teachersresources.html

Three States of Matter is a fun song that reinforces the most important concepts in this lesson. We strongly encourage you to download the music and have your students sing along.

You can end the day by reading one of the following books out-loud to your class:

Royston, Angela. *My World of Science: Solids, Liquids and Gases*. Crystal Lake, IL: Heinemann Books, 2001.

Zoehfeld, Kathleen. *What Is The World Made Of? All About Solids, Liquids, and Gases*. New York: Harper Collins Publishers Inc., 1998.

LESSON TWO: *What is Matter Made of?*

Objectives:

- Students will learn that MATTER is made of ATOMS.
- Students will learn how ATOMS move in different STATES of MATTER.
- Students will learn how small ATOMS are.
- Students will review the three STATES of MATTER.

Introduction:

1. Review by eliciting the THREE STATES of MATTER and examples of each. It is useful to write them on the board.
2. Explain that scientists have discovered that all MATTER is made of very, very small particles called ATOMS. Tell them the differences in the STATES of MATTER are due to the different types of ATOMS, the arrangement of the ATOMS, how they move and how closely they are packed.

DEMONSTRATION: *Model of Atomic Motion*

Materials:

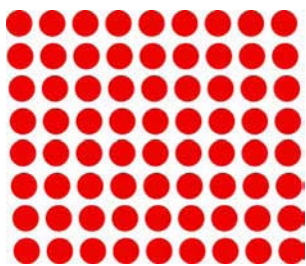
- A clear plastic container with a lid (clear plastic cups work well)
- Enough marbles (super balls, gum balls or beads) to fill the container.

Procedure:

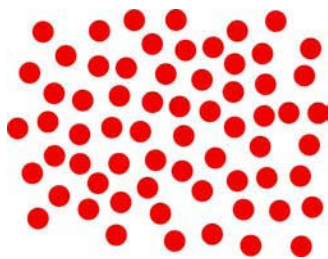
1. Explain that ATOMS are very, very small. So small that we can't see them without special microscopes, so scientists often use MODELS to represent how they look and act. Explain that spheres or balls are often used to represent ATOMS because ATOMS sometimes act like spheres. Take out a marble and explain that in this demonstration each marble represents an ATOM.
2. Take out the plastic container completely full of marbles. Explain that this is what the ATOMS in a SOLID act like. They are in a fixed arrangement so they do not move around. Shake the container to show that none of the ATOMS change their position, they just vibrate in the same place. Explain that this arrangement of ATOMS is why SOLIDS are hard and keep their shape.
3. Tell them you are going to turn up the temperature. Take out a bunch of the marbles (about $\frac{1}{3}$ - $\frac{1}{2}$) so that the others can move around as you move the container. Explain this is how the ATOMS in a LIQUID behave. They are still close to each other but don't stay in one place. Tilt the container to one side and show how a liquid flows and takes the shape of the container. Take off the lid and pour all of the marbles into a cup to emphasize how they flow.
4. Tell them you are now really going to turn up the heat. Put a few of the marbles back into the container. Explain that there is a lot of space between the ATOMS of a GAS and that they are moving very fast. Ask why they are moving so fast. Emphasize, that an increase in temperature is an increase in energy, which increases the speed that the atoms move. Shake the container so that the marbles bounce around hitting the sides and each other. Explain that

this is what the ATOMS in a GAS are doing, moving around very fast filling the entire container and colliding with each other.

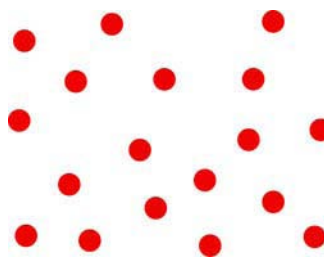
5. Remind them ATOMS are so small that we can't see them. Gases are a good example of this.
6. Take out the diagrams (see Appendix) and have the class identify which state each diagram represents. As they do, hang them on the board under the name of each state.



SOLID



LIQUID



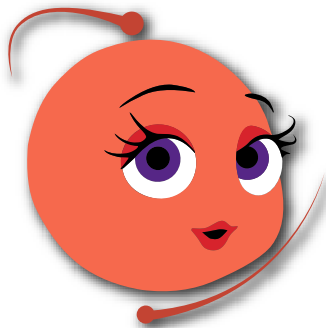
GAS

ACTIVITY: *Act like ATOMS*

1. Tell the kids that they are going to have a chance to act like ATOMS as they change through the different STATES OF MATTER. Review the differences. ATOMS in SOLIDS have a fixed pattern and don't change position. ATOMS in LIQUIDS move around a bit and change their location. There is a lot of space between ATOMS in a GAS and they move around very fast, changing their position and filling the entire container.
2. Have every one stand up. Begin by having everyone get lined up in rows, close together and facing the same direction (this may be the way their desks are already arranged.) Tell them they are all ATOMS. Ask them what STATE they are in.
3. Now tell them to start to move around in the same general area. As they do they will break the rows and continue to change their locations. Ask them what STATE they are now in.
4. Ask them what is the other STATE of MATTER. When they answer GAS, ask them how the ATOMS in a GAS behave. Tell them to act like a GAS. Encourage them to run all over the room and bounce off the walls. After you have had enough, call everyone back over for an introduction.

Introduction: *Allow me to introduce Oxy*

Tell them that you would like to introduce them to one of the most important ATOMS in the UNIVERSE. Explain that you are going to get some help teaching the class about ATOMS by introducing them to some ATOMS from an exciting new animation called **Molecularium**. You can explain that they are imaginary characters and unlike real ATOMS, they can talk and sing.



Take out the picture of OXY and introduce her. "This is Oxy. She is an OXYGEN ATOM." Ask if anyone has ever heard of OXYGEN. (Many students will be familiar with the word and may know that we breathe it.) Discuss how OXYGEN is very important to human life. We need to breathe OXYGEN to stay alive! Oxygen is also an important element of water. Explain that they will learn a lot about Oxy in the coming lessons. Remind them that atoms are very, very small. Tell them Oxy wants to show them how small but she needs their help making a life size model.

ACTIVITY: HOW SMALL ARE ATOMS?

Materials:

- Strips of paper 28 cm (11 inches)
- Scissors

Procedure:

1. Give everyone a strip of paper and scissors.
2. Tell students that if they can cut the strip in half 31 times, they will be able to see how small ATOMS are.
3. Have them fold their piece of paper in half and cut it into equal halves. Have them say "ONE". Encourage them to keep track of the number of cuts by counting them out-loud or writing it down as they go. Have them cut one of these pieces in half and say "TWO".
4. Have them continue this process, cutting each new piece in half, until they give up. The chart below gives some comparisons for them to think about.

Cut 1	14.0 cm	5.5"	CHILD'S HAND, POCKETS
Cut 2	7.0 cm	2.75"	FINGERS, EARS, TOES
Cut 3	3.5 cm	1.38"	WATCH, MUSHROOM, EYE
Cut 4	1.75 cm	0.69"	KEYBOARD KEYS, RINGS, INSECTS
Cut 6	0.44 cm	0.17"	POPPY SEEDS
Cut 8	1 mm	0.04"	THREAD. CONGRATULATIONS IF YOUR STILL IN!
Cut 10	0.25 mm	0.01"	STILL CUTTING? MOST HAVE QUIT BY NOW
Cut 12	0.06 mm	0.002"	MICROSCOPIC RANGE, HUMAN HAIR
Cut 14	0.015 mm	0.006"	WIDTH OF PAPER, MICROCHIP COMPONENTS
Cut 18	1 micron	0.0004"	WATER PURIFICATION OPENINGS, BACTERIA
Cut 19	500 nanometers	0.000018"	VISIBLE LIGHT WAVES
Cut 24	15 nanometers	0.0000006"	ELECTRON MICROSCOPE RANGE, MEMBRANES
Cut 31	0.1 nanometers	0.000000045"	THE SIZE OF AN ATOM!

Note: 1 micron is 1/1,000,000 of a meter. 1 nanometer is 1/1,000,000,000.

Source: This activity as been adapted from a lesson by the Miami Museum of Science

<http://www.miamisci.org/af/sln/phantom/papercutting.html>

Expand:

It should be clear to everyone that ATOMS are very, very small, but it may still be difficult to imagine just how small. Here are some other comparisons for them.

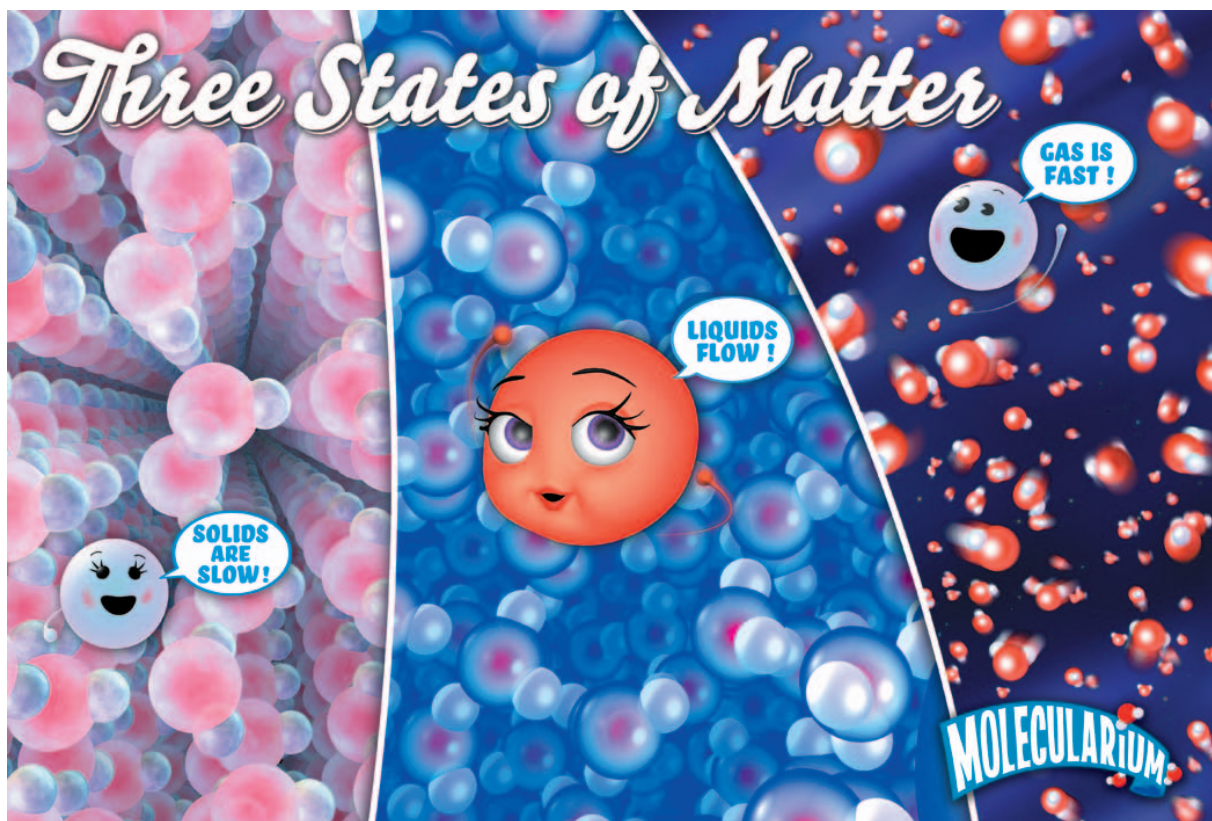
- If a hydrogen ATOM was the size of a soccer ball, then a soccer ball would be 6450 kilometers (4008 miles) in diameter. That is much bigger than the United States.
<http://library.thinkquest.org/17940/texts/ATOM/ATOM.html>
- Now take a baseball and blow it up to the size of the earth... the ATOMS inside the baseball are now the size of grapes
<http://static.stii.dost.gov.ph/INFOSCIENCE/jun2001/jun01.6.htm>
- A very fine pencil line's width is 3,000,000 ATOMS across.
- The smallest speck of dust contains about 10,000,000,000,000,000 ATOMS!
<http://scienceteacher2.info/ATOMS1.htm>

GAME: *Mel Says*

Tell them they are going to play a game called “Mel Says”. Explain that Mel is the name of the computer of the Molecularium, the most fantastic ship in the Universe. It is the most fantastic ship because it can go anywhere and travel through the nanoscale world of atoms. The game is played just like Simon Says, except in this case Mel says “Act like a Gas” “Act like a Liquid” or “Act like a Solid.” The point of the activity is to reinforce the lesson, but since most of the kids like games and will be familiar with Simon Says, you can throw them off by throwing in some commands like “Touch your toes.”

SONG: *So Small*

A great way to reinforce how small atoms are is with Oxy’s solo number “I’m so small.”



LESSON THREE: *Atoms Make Molecules*

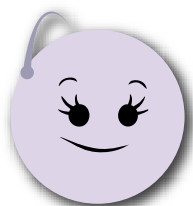
Background: In this lesson, you will get some help teaching your class about ATOMS and MOLECULES by introducing them to the characters of Molecularium. The goal is to excite them by bringing them into the world of ATOMS and MOLECULES.

Objectives:

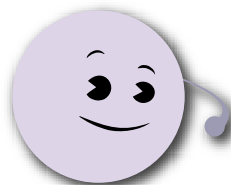
- Student will learn that ATOMS bond together to make MOLECULES.
- Students will be introduced to ELEMENTS and the PERIODIC TABLE.
- Students will learn that ATOMS have ELECTRONS
- Students will learn about OXYGEN, HYDROGEN and H₂O
- Students will observe the motion of MOLECULES in a LIQUID
- Students will be introduced to the characters of the Molecularium

Introduction: *Let me introduce you to some amazing Atoms!*

1. Review by asking what everything is made of. Ask what MATTER is made of.
2. Explain that there are many different kinds of ATOMS. Anything made of just one kind of ATOM is called an ELEMENT. Scientists have identified 116 different ELEMENTS. Some of the ELEMENTS (like GOLD, SILVER and COPPER), have been known to people for thousands of years, but most have only been discovered by scientists in the last 250 years. Scientists have organized them into a chart called the Periodic Table of Elements. Show them a copy of the Periodic Table. Point out that all of the ELEMENTS are symbolized by one or two letters. Point out OXYGEN on the Periodic Table.
3. Tell them that you would like to introduce them to some of Oxy's best friends and some of the most important ATOMS in the UNIVERSE.



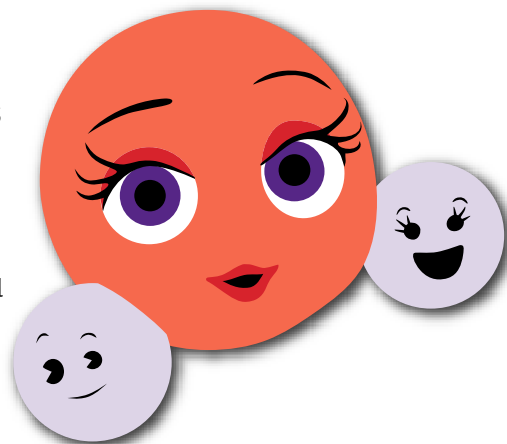
Hydra



Hydro

Take out the picture of HYDRA and HYDRO and introduce them. Tell them they are HYDROGEN ATOMS. Explain that HYDROGEN is the most common ELEMENT in the UNIVERSE (90%). It is also the smallest and most basic. Point it out on the periodic table. Notice that it is alone at the top of the chart and that its ATOMIC NUMBER is one. At room temperature, it is a GAS. Explain that HYDRA and HYDRO are great friends because HYDROGEN loves to join (BOND) with other HYDROGENS to make H₂.

4. Explain that all ATOMS have ELECTRONS. Point out that HYDROGEN has only one ELECTRON. Explain that when HYDRO and HYDRA BOND they share electrons and stay stuck to each other. It is like they are holding hands.
5. Point out OXYGEN on the Periodic Table. Note that OXYGEN is bigger than HYDROGEN . OXYGEN is also a GAS at room temperature and also likes to BOND with other OXYGEN ATOMS to make O₂. O₂ makes up 23% of the air in the Earth's Atmosphere. Point out that OXYGEN'S ATOMIC NUMBER is 8.
6. Explain that OXYGEN has eight ELECTRONS but that usually only two of them are free to BOND. Therefore, OXYGEN often bonds with two different ATOMS. When it makes O₂ , it is like holding both hands. It is useful to have two kids come up to the front of the class to demonstrate this.
7. There are only 114 other elements and only 92 of them occur naturally. Talk about how that really isn't that many. Talk about how many different things there are in the UNIVERSE.
8. Explain when ATOMS BOND to other ATOMS they make totally new things called MOLECULES. MOLECULES are made of two or more ATOMS. They can be the same kind of ATOMS, like H₂ and O₂, but they don't have to be. Most MOLECULES are made of different kinds of ATOMS. Explain that MOLECULES made of more than one element are called COMPOUNDS. Most of the things in the universe are made of MOLECULES that are made up of different combinations of ATOMS. Tell them that OXYGEN and HYDROGEN are an excellent example.
9. Tell them that OXY is very good friends with HYDRO and HYDRA. Since OXYGEN ATOMS have two open ELECTRONS, it often BONDS with two HYDROGEN ATOMS to make a very important MOLECULE. Show them the picture of H₂O and ask if anyone knows what it is called. If no one does, ask if anyone has ever heard of H₂O. Since this is a familiar term, someone in the class may know what it is. If not, give them the following clues and have them guess:



1. 70% of the human body is made of it.
 2. 70% of the Earth's surface is covered with it.
 3. Most people drink it everyday.
10. Explain that MOLECULES, just like ATOMS, go through the three STATES of MATTER. Review the different states by recalling the ice melting demo from Lesson one. Discuss how in each state the MOLECULES remain H₂O, the only difference is how they are arranged and move. Review the ways ATOMS behave in the different STATES of MATTER.
 11. Remind everyone that H₂O MOLECULES are incredibly small. You can reinforce this idea with the following:
 - There are approximately 1.67 sextillion (1.67 x 10²¹) MOLECULES of H₂O in a single drop of water. <http://www.madsci.org/posts/archives/oct2000/971190308.Ch.r.html>
 - This is a huge number. Write it out on the board. (Discuss scientific notation by explaining that 21 is the number of places to move the decimal point, so you need to add 19 zeros.) Here are some other numbers for comparison. Write them on the board. [Note: All of these

numbers are rough estimates based on various calculations. The point is to emphasize the vast number of MOLECULES. Sources have been included.]

- There are about 6.5 billion (6.5×10^9) people on Earth now.
- (Some) Scientists have estimated there are 7.5 quintillion (7.5×10^{18}) grains of sand on all of the world's beaches. <http://www.miamisci.org/tripod/whysand.html>

ACTIVITY: Lets Make Models of MOLECULES!

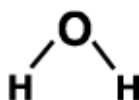
Making models of MOLECULES is an excellent way to connect kids to the concepts. You should experiment with a variety of materials and make a variety of models. The suggestions listed are some possibilities, but you are encouraged to come up with your own. One of the main considerations is size. Ideally, the oxygen ATOMS will be larger than the hydrogen ATOMS.

Materials:

	Marshmallows	Gumdrops	Balloons	Fruit
Oxygen	Regular size	Large	Inflate more	Grapefruit
Hydrogen	Mini size	Small	Inflate less	Tangerines
Bond	toothpicks	toothpicks	double sided tape	toothpicks

Procedure:

1. Set up a number of MOLECULE building stations. At each, have containers holding the different kinds of ATOMS and bonding materials. You can label each container, so it is clear what kind of ATOM is in each. Make sure everyone understands that oxygen is larger than hydrogen.
2. Tell everyone that they are going to make models of water MOLECULES. Ask if anyone remembers the chemical formula of water.
3. Explain that scientists often draw models using letters and lines. Draw a picture of H_2O on the board :



4. Show them the picture of H_2O from Molecularium and point out the bond angle of the hydrogen ATOMS (104.5° in liquid).
5. Allow them to build models out of the materials supplied. Demonstrate how to do it if necessary.

Discussion:

After the students have made models of H_2O , discuss that MOLECULES go through the three STATES of MATTER, just like ATOMS. Review the three STATES of MATTER and the motion and arrangement of ATOMS in each. Explain that MOLECULES also behave like this. Have them demonstrate the different states of H_2O with their models: Solid - close together in a fixed pattern and not changing position; Liquid - moving around but still close to each other; Gas - moving all around the room quickly.

ACTIVITY: *The Motion of MOLECULES in a Liquid*

Materials:

- 3 clear containers (beakers, glasses or clear plastic cups)
- Red or blue food coloring
- Water at three different temperatures (hot, room, cold)

Procedure:

1. Fill the three containers with different temperature water. (Note: The hotter and colder, the better)
2. Allow them to sit for a little while so the water stops moving. Be sure the containers are on a stable, unmoving surface. Be careful not to bump or move them.
3. Put a couple of drops of food coloring in each of the containers.
4. Observe carefully the movement of the coloring and how long it takes for the coloring to become completely mixed in the water.

Discussion:

Have students discuss what they observed. Which was moving fastest? Slowest? Ask for ideas about what was causing it to move. What STATE is the water in? Discuss how this experiment shows how MOLECULES are always moving in a liquid. Their movement is related to temperature. As they just demonstrated, the hotter the water is, the faster the MOLECULES are moving.

ACTIVITY: *Let's Become MOLECULES!*

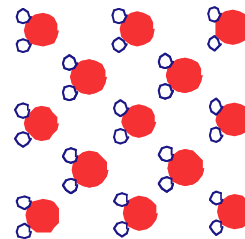
Materials:

- Character pictures for the whole class (1/3 Oxy, 1/3 Hydro, 1/3 Hydra)
- Tape

Procedure:

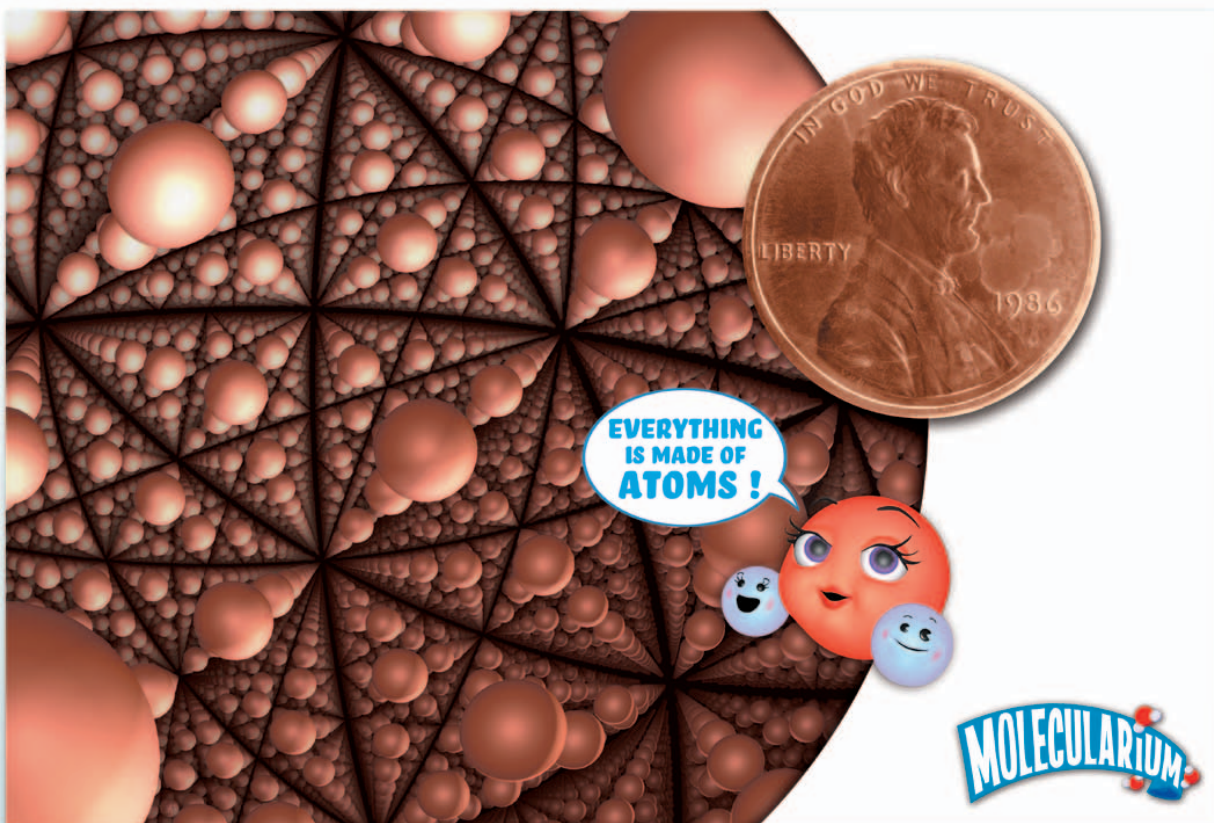
1. Tell everyone to "Prepare to get really small." Tell them that they are going to become ATOMS and make MOLECULES.
2. Give everyone a character picture and have them tape it on the front of their shirt. Ask everyone what kind of ATOM they are.
3. Start by having everyone BOND with other ATOMS like them and make H₂ and O₂. They should BOND by holding hands. Ask everyone what they are now, and be sure that they understand that when they are bonded together they make MOLECULES.
4. Now have them UNBOND and tell them to make H₂O MOLECULES.
5. Repeat this process a number of times, each time they should move around and BOND with different ATOMS.
6. Have everyone take a break to review the motion of ATOMS in the different STATES. (Recall how they acted as ATOMS in Lesson 2.) Explain that MOLECULES act just like the ATOMS in the different STATES. Make clear that the MOLECULES stay bonded to each other even as the temperature increases or decreases. Have everyone bond again into water MOLECULES. Tell them that they are part of a snowflake. Ask what STATE they are in. Explain the MOLECULES in an ice crystal are in a special arrangement. Show them the diagram and help them get arranged into staggered rows. Be sure to point out that they are a very, very small part of a snowflake.

7. Tell them that it is a warm day in the winter and the snowflake lands on a warm sidewalk. Ask what they think happens to the snowflake. Ask what STATE it changes into. Have them become LIQUID. Be sure they stay bonded as they start to move around.
8. Tell them that the sun is very strong that day and dries the sidewalk. Ask what happens to the water MOLECULES. (Recall the ice cube melting exercise from Lesson 1.) Ask them what state they become. Have them act like a GAS. Again, be sure they stay bonded.



SONG: H_2O

This song reinforces that atoms make molecules, that HYDROGEN and OXYGEN make water and that there are three states of matter. You can divide the class into the different roles and sing along with the characters.



LESSON FOUR: *Molecular Fun - Chemical Reactions*

Objective:

- Students will learn about chemical reactions
- Students will learn that a chemical reaction is when ATOMS and MOLECULES react with each other to make or break bonds and form new arrangements
- Students will learn about CARBON
- Students will learn that all chemical reactions result in a change in energy

Review:

Begin by reviewing the major concepts covered so far. Here is a brief summary.

- All things are made of MATTER.
- MATTER takes up space.
- MATTER is made of ATOMS.
- The STATES of MATTER - (Solid- slow; Liquids- flow; Gas- fast)
- The STATES of MATTER are a result of the arrangement and movement of ATOMS.
- Increasing the temperature (ENERGY), increases the movement of ATOMS and MOLECULES.
- ATOMS are incredibly small. (BILLIONS and BILLIONS)
- There are many kinds of ATOMS (The Periodic Table of ELEMENTS)
- Oxygen and Hydrogen are common, important elements.
- ATOMS BOND to make MOLECULES.
- O₂ is a common gas.
- Water is an H₂O MOLECULE.

Background:

The study of how ATOMS and MOLECULES react with each other is called CHEMISTRY. We have learned how HYDROGEN and OXYGEN can BOND with each other to form H₂O and make water. This BONDING is a CHEMICAL REACTION. A CHEMICAL REACTION takes place when different ATOMS and MOLECULES react with each other by making or breaking bonds and forming new MOLECULES.

DEMONSTRATION: *Blow up a Balloon with a Chemical Reaction*

Materials:

- A small bottle (16 oz. soda bottles [or smaller] work well)
- A medium-sized balloon
- Vinegar
- Baking soda
- A funnel

Procedure:

Note: As you conduct this demonstration, you should review by asking the different states of the different materials used (i.e. What state is the vinegar? The baking soda?)

1. Pour vinegar into a small bottle until it is about half an inch deep.
2. Using a funnel or a paper cone, pour two teaspoons of baking soda into the neck of a balloon.

3. Stretch the neck of the balloon over the neck of the bottle, being careful not to let the baking soda out of the balloon.
4. Lift up the balloon so that the baking soda falls into the vinegar. Shake the bottle.
5. Observe what happens.
6. Reinforce the concept of a CHEMICAL REACTION by putting some water in a glass and vinegar in another.
7. Have students predict what will happen if you put baking soda in the water.
8. Add 2 tsps and observe.
9. Do the same for the vinegar.

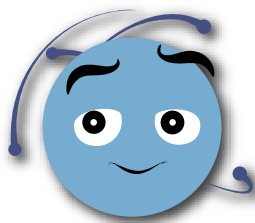
Discussion:

Talk about what happened. What is in the balloon? Explain that vinegar and baking soda REACT with each other to form totally new MOLECULES. In this chemical reaction, the vinegar and baking soda react and create carbon dioxide gas which makes bubbles and inflates the balloon. Note that water did not react with the baking soda. Explain that vinegar and water are made of different ATOMS, so they react differently.

To better understand what is happening it is useful to introduce a new element- Carbon.

Expand: Carbon is Incredible! - Allow me to introduce *Carbón*

Recall the Periodic Table of Elements and review the elements that you have introduced so far. It is useful to use the characters to do this. Show them the picture of Oxy and ask who she is. Ask what kind of ATOM she is. Do the same for Hydro and Hydra.

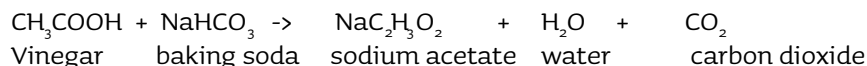


Tell them you are going to introduce them to another very important element. This element is very important because it is essential to all life. Take a picture of Carbón and introduce him. He is a CARBON ATOM. Ask how many bonding ELECTRONS CARBÓN has. Explain that because CARBÓN has four open ELECTRONS it BONDS with many other ELEMENTS to make an incredible number of different MOLECULES. (Scientists have identified millions of CARBON compounds.)

Explain that both vinegar and baking soda have CARBON in them. When they are mixed together a CHEMICAL REACTION happens and the MOLECULES rearrange forming new MOLECULES. One of them is the gas CO₂. Discuss how CARBON has four open ELECTRON and OXYGEN has two, so two OXYGEN ATOMS easily BOND with one CARBON ATOM. Explain that CO₂ is a gas that humans exhale all of the time. It is also the gas in carbonated drinking soda.

It is beyond the scope of this guide to go into chemical reactions in great detail. The goal is to get students to understand that CHEMICAL REACTIONS are a rearrangement of MOLECULES by breaking and making BONDS and that CHEMICAL REACTIONS are happening around and inside of us all of the time.

For those interested here is the CHEMICAL equation of the reaction in the experiment.



ACTIVITY: *Fun with CO₂*

Here is a fun, but messy experiment that kids love. Be prepared to do some clean up. Of course, basic safety precautions should be taken.

Materials:

- Plastic film canisters (White Fuji Film® canisters work best. Ask for them anywhere film is developed. They will usually have a bunch you can have for free.)
- Alka-Seltzer® tablets (at least one per group)
- Water

Procedure: Part 1

1. Divide the Alka-Seltzer tablet in half. Save half for part two. Divide the other half in two. (A total of 3 pieces.)
2. Fill the film canister 1/3 full with water. Put it on table that can get wet.
3. Put 1/4 of the Alka-Seltzer tablet in and quickly snap the lid on.
(A good technique is to hold the lid upside down and put the piece of the tablet on the lid. Then when you put the lid on the canister it will drop in automatically. Be sure that the lid is dry if you use this technique.)
4. Start the stopwatch and STAND BACK. (Be careful not to point the canister at anyone or yourself.)
5. Record how long it takes for the top to pop.
6. Have them repeat the experiment with the other quarter tablet and compare the times.

Discussion:

Talk about what happened. Why did it happen? Discuss how the chemical reaction created CO₂ gas (just like in the balloon experiment). Remind them how GAS (just like all matter) takes up space. As more CO₂ is created by the reaction, it pushes harder and harder against the sides of the container until it finally takes up too much space and pops the top.

Procedure: Part 2 - CO₂ Rocket

Note: This is best done outside on a concrete or asphalt surface!!!

1. Fill the canister half full of water.
2. Put 1/4 of the Alka-Seltzer tablet in the container and put on the lid quickly. Start timing.
3. Quickly put the container on the ground upside down
4. STAND BACK (at least two meters).

DEMONSTRATION: *Fire is a Chemical Reaction*

Background: Fire is a chemical reaction. Not only is oxygen essential for life, it is also essential for fire. All fires need three things: fuel, heat and oxygen. Heat and light are two products of this chemical reaction.

Materials:

- 3 identical candles (small birthday candles work well)
- 3 different-size glass jars (that fit over the candles)

- Matches or lighter
- 3 pieces of cardboard
- Clay

Procedure:

1. Using the clay, fasten a candle to each piece of cardboard.
2. Light the candles and explain that fire is a chemical reaction.
3. Review by asking what is in the jar. (Remind them of Lesson 1 - Demo #1: Air takes up space.)
4. Place the jars over the candles at the same time.
5. Observe what happens.

Discussion:

Discuss why the candles went out. Ask which one burned the longest. Why? Discuss how when all of the OXYGEN is used up, the flame goes out. Discuss how the largest one contained the most OXYGEN in the jar and therefore burned the longest. Suffocating a fire, depriving it of OXYGEN, is one of the best ways to put out a fire, especially a small one. Explain that some fire extinguishers suffocate fires by covering them in foam that prevents them from getting oxygen. Covering a campfire with dirt has the same effect. Fanning a fire feeds it more OXYGEN and has the opposite effect.

If you wish to expand the discussion to fire safety, you can talk about how breathing OXYGEN is essential to staying alive. Since fires use a lot of OXYGEN, most people that die in fires die from a lack of OXYGEN and not getting burned. The smoke of a fire is very dangerous because it can suffocate you, which is why you should always stay low to the ground during a fire.

DEMONSTRATION: O₂ and CO₂ are very different

Materials:

- a glass tumbler or beaker
- clay
- a candle
- Alka-Seltzer tablets

Procedure

1. Fasten the candle to the bottom of the tumbler with the clay.
2. Fill the cup with water so that it is at least 3 cm from the top of the candle.
3. Light the candle and let it burn. Remind them that the flame is using oxygen (O₂) from the air.
4. Have students predict what will happen when you put an Alka-Seltzer tablet in.
5. Drop an Alka-Seltzer tablet into the cup of water.
6. Observe what happens to the flame.

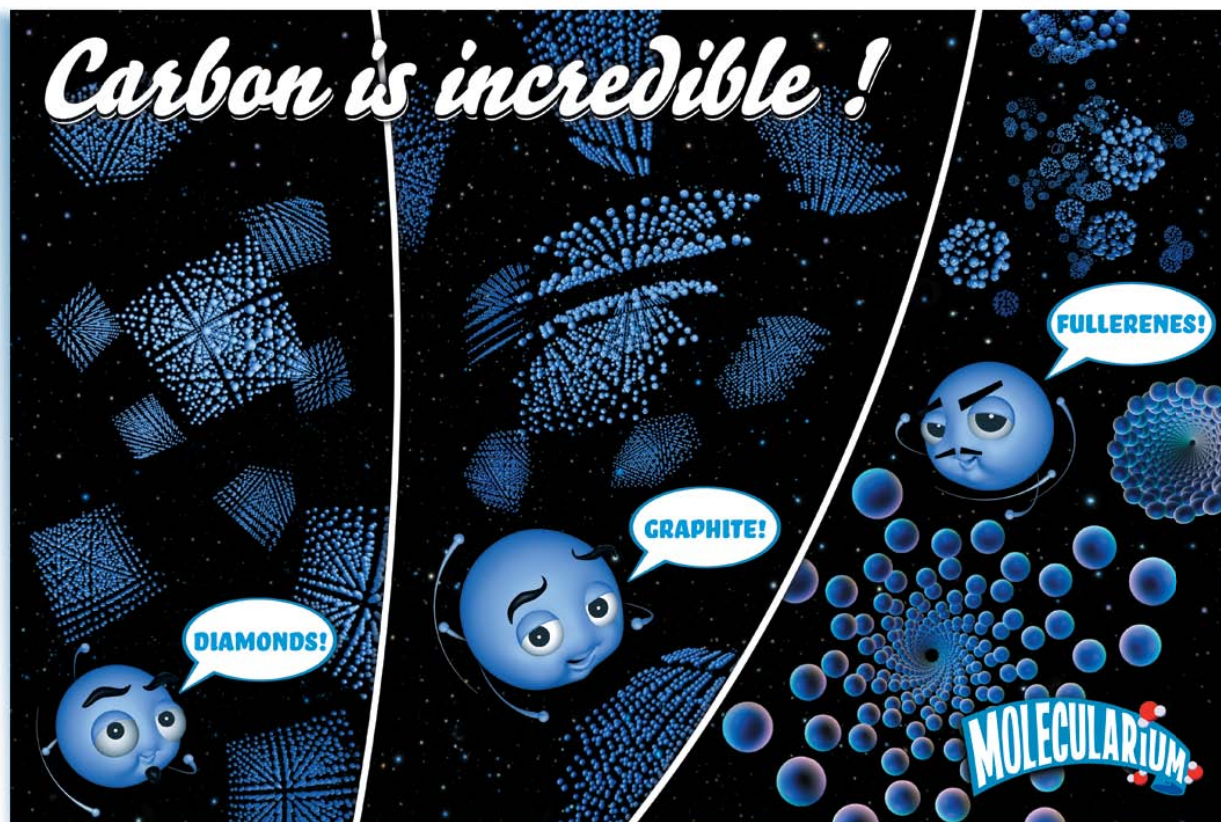
Discussion:

What does a flame need to burn? Ask what was produced when you put the tablet in the water. Does the CO₂ help the flame? Is CO₂ flammable? Ask why they think the flame went out. Discuss how the environment around the flame changed from normal air with 21% O₂ to mainly CO₂. The CO₂ prevents the flame from getting O₂. As a result, the flame is extinguished. Many fire extinguishers use pressurized CO₂ to put out flames.

Discuss how the properties of O_2 and CO_2 are very different. O_2 is necessary for fire; CO_2 puts fires out. Even though both MOLECULES have two oxygen ATOMS, they have opposite effects on fire.

SONG: *Carbon is Incredible!*

CARBON loves to BOND with other ELEMENTS, but it also likes to BOND with itself to make some incredible materials like diamonds, graphite and the newly discovered fullerenes (bucky balls.) This fun song from **Molecularium** reinforces just how incredible CARBON is.



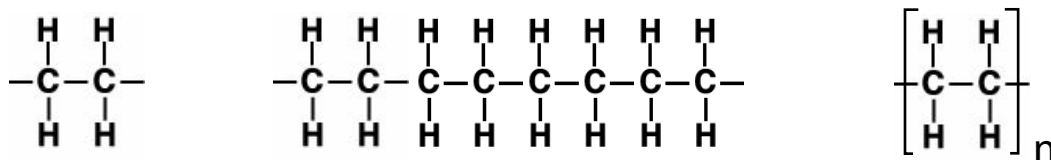
LESSON 5: *Polymers - Some Very Long Molecules*

Objectives:

- Students will learn what a MER is
- Students will learn what a POLYMER is
- Students will make models of POLYMERS
- Students will make a POLYMER and identify its properties

Background: Some ATOMS, particularly CARBON ATOMS, can join together in long chains to form very long MOLECULES called POLYMERS. The word comes from the Greek “poly” meaning many and “mers” meaning parts. POLYMERS are formed from long chains of the same smaller MOLECULE called MERS (or MONOMERS) repeated over and over again (often referred to as a “repeat unit”.) These long chains can get entangled with each other, linking together in many different complex ways, making polymers both strong and very versatile. The properties of a polymer are determined by a variety of factors including the basic MER, how many are joined together and the degree of entanglement and crosslinking.

Most people think of plastic when they hear the word “polymer”, but there are many naturally occurring POLYMERS like rubber, cotton fibers, silk, proteins and cellulose. Synthetic or man-made POLYMERS were first discovered in the late 1800’s. Nylon, the first synthetic fabric, was discovered in 1934. Today, synthetic POLYMERS are everywhere and found in almost every product manufactured (especially the packaging).



This is a MER (repeat unit) of POLYETHYLENE. Note how it links to identical MERS to form a long chain. Polyethylene is the most commonly used POLYMER. It is used for plastic bags, cling wrap, plastic bottles, shower curtains, as well as many other useful things.

ACTIVITY: *Polymer Model*

Materials:

- Paper Clips (at least five for each student)

Procedure:

1. Give each student at least five paperclips. Explain that each paperclip represents a MER (or MONOMER).
2. Have them link their MERS together into a chain.
3. Have each row of students link their chains together. Explain that each of these chains represents a POLYMER.
4. Have them entangle these chains by linking them together randomly to represent how polymer chains cross link. Explain that physical mixing entangles the different polymers.
5. Show that untying the chains is very difficult. This demonstrates the durability of polymers and shows why most do not breakdown (or degrade) easily.

- Expand by having students stand in a marked off area. Each of them represents a MER. Have them move around and notice how easy it is. Have them join hands to make one long POLYMER chain. Have them notice that it is harder to move while they are connected in a chain.
- Now you can crosslink the chain by holding on to the clasped hands of the students at two different points in the chain. Have them notice how it is even harder to move when the chain is crosslinked.

Discussion:

Discuss how the models demonstrate the strength and flexibility of POLYMERS. Talk about how cross-linked polymers are less flexible. Discuss how common POLYMERS are. Have everyone look around the room and name different things that are made of POLYMERS.

ACTIVITY: Produce a Polymer (GLUEP)**Materials:**

- Elmer's Glue
- Disposable plastic cup
- Borax
- stir sticks or plastic spoons

Procedure:

- Prepare a saturated borax solution by adding a tablespoon of Borax to a cup of water. If all of the powder dissolves, add more until you reach the point that no more will dissolve (saturation). **[WARNING:** The borax solution should be handled with care. It can irritate the eyes so don't rub your eyes until you have washed your hands. Younger children should have the borax solution measured out for them.]
- In a disposable cup, mix 25 ml (5 tsp.) of Elmer's® Glue with 20 ml (4 tsp.) of water. Mix well with a stirrer. (You can add a couple of drops of food coloring if you wish to give your polymer some color.)
- Add 5ml (1 tsp.) of the borax solution and stir quickly for at least two minutes. If there is more liquid in the cup or if it is very sticky, add 4-5 drops of the Borax solution.
- Remove the polymer from the cup with the stirrer and roll it into a ball in your hands. Knead it in your hands for several minutes until it starts to form a nice blob.
- Encourage students to play with their polymer and make observations. Encourage them to roll it, bounce it, stretch it quickly, then slowly and notice the differences.
- Put their polymers in a plastic bag to take home.

Discussion:

Talk about their results. What happened when they mixed the materials together? (Recall the last lesson.) Talk about the chemical reaction that occurred and how they crosslinked a polymer through a CHEMICAL REACTION. Have them describe how this polymer looks, feels, smells and behaves.

(WARNING: Do NOT Taste or Eat GLUEP). Ask why they think it feels wet. Explain that there are water MOLECULES trapped throughout the many POLYMER chains, but they are not part of the POLYMER. If it is not stored in a vapor-proof container, the water will evaporate and the POLYMER will dry out. What do they think will happen if it dries out?

Talk about how so many of the things around them are made of different types of polymers. Emphasize that all of them are made of atoms and molecules.

ACTIVITY: *How Much Polymer is in Your Favorite Gum?*

Materials:

- Triple Beam Balance
- Variety of Gum (both sugarless and not sugarless)
- Large Chart Paper

Procedure:

1. Prior to the activity, make the following chart on the board or on a large sheet of paper. You will need the same number of rows as students.

Name of Student	Name of Gum	Weight Before Chewing	Weight After Chewing	Weight loss (amount of sugar and flavorings)	Percentage of polymer (weight after/weight before x 100)

2. Record the type of gum that each student is given on the chart.
3. Show students how to use the triple beam balance to weigh the gum in the wrapper. Have them record this on the chart in the column next to their gum.
4. Now, have the students remove the gum from the wrapper and set the wrapper aside for later use. Have them chew their gum continuously for ten minutes.
5. After chewing the gum for ten minutes, have them dry the gum, put the gum back in the wrapper and weigh it again.
6. Subtract the weight after chewing from the weight before to find out how much weight has been lost. Ask students why they think weight was lost. This is the amount of sugar and flavorings.
7. Calculate the percentage of polymer in each type of gum by dividing the weight after chewing by the weight before chewing and multiplying by 100. Record this on the chart paper.
8. Compare the amount of polymer in each type of gum. Which type of gum had the most polymer? Is there a difference between sugarless and regular gum?

*Accuracy is important when weighing the samples. Make sure to oversee the students as they are using the triple beam balance.

Discussion:

Talk about their results. Discuss why there is a weight difference after chewing. Explain that the sugar and flavorings are soluble and dissolve in your mouth. The POLYMER gum base is not soluble and so it remains. Which kind of gum lost the most weight? What does that mean? Compare sugarless gums to the rest.

SONG: *Atoms Are Amazing!*

A fun way to finish up these lessons and review the most important concept is with the grand finale of the show, *Atoms Are Amazing!*

*Molecularium™ Vocabulary*¹

atom - smallest piece of an element that maintains the properties of the element

boiling point - temperature at which a liquid changes to a gas

bond - an attraction between atoms that holds them together

carbon – an incredible element that loves to bond with other small atoms. Its compounds are the basis of all life. Pure forms of carbon include diamond, graphite and fullerenes.

compound - a chemical consisting of two or more elements chemically bonded together

condensation - to change from a gas to a liquid

density - the amount of matter (mass) packed into a space or mass/unit volume

dissolve - to mix the molecules or atoms of one substance with another. The mixture is often called a solution

elements - a substance that can't be broken into a simpler substance by chemical means

evaporation - to change from a liquid to a gas

expand - to make bigger

freezing point - the temperature at which a liquid becomes a solid

gas - a form of matter in which the molecules form no definite shape and are free to move about to uniformly fill any container (gas is fast, liquids flow, solids slow).

hydrogen - the smallest, most common atom

liquid - a form of matter that has a fixed volume but no fixed shape (gas is fast, liquids flow, solids slow)

mass - the amount of matter in an object

matter - has mass and takes up space, everything is made of matter

¹ **Reference:** KNAPP, BRIAN. CHEM LAB GASES, LIQUIDS, AND SOLIDS. (1998) ATLANTIC EUROPE PUBLISHING COMPANY LIMITED STUDENT VOCABULARY & ; PICKETT, JOSEPH, ET AL. THE AMERICAN HERITAGE CHILDREN'S SCIENCE DICTIONARY. (2003) HOUGHTON MIFFLIN COMPANY, NEW YORK.

melting point - temperature at which a solid becomes a liquid

mer - a repeat unit or a part

mixture - a material that can be separated into two or more substances using physical means

molecule - a group of two or more atoms held together by chemical bonds

oxygen - a chemical element essential for most living organisms and fire

poly - many

polymer - many repeat units, a compound that is made of long chains by combining molecules (mers) as repeating units (plastics)

solid - a rigid form of matter that maintains its shape (gas is fast, liquids flow, solids slow)

states of matter (phases of matter) - the three forms that matter may take, solid, liquid, gas

temperature - degree of heat or cold

volume - the amount of space that an object takes up

water cycle - the process in which water moves through the ground, evaporates from earth into the air, forms clouds, and falls back to earth as rain or snow

Acknowledgements

This guide draws from a wide variety of sources. Most of the experiments included in this guide can be found in many different forms on the internet, so it is difficult to say who originated them. Glue P(also know as Gak), the last experiment included, is a fine example. There are hundreds of recipes for it on the internet, yet I am not sure anyone knows who first made it. This guide is a compilation of a series of experiments and lessons in a useful order to introduce kids to atoms, molecules and many of the concepts related to them.

Special thanks to Linda Schadler for being the driving force behind the Molecularium Project from its inception and for providing many helpful suggestions during the compilation of this guide (as well as proofreading it.)

This guide is also indebted to Lisa Scorzelli and Tracey Bennett of Guilderland Central School District for editing the first edition of the Molecularium Resource Guide in collaboration with Linda S. Schadler and Jayne E. Architzel. Though it has changed a lot, this guide draws on their hard work. Special thanks to Deirdre Schadler.

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* K-5

** K-2

*** 3-5

Student Vocabulary Flash Cards (Page 1 - Side 1)

atom	boiling point	bond
compound	condensation	crystals
density	dissolve	elements
evaporation	expand	freezing point
gas	liquid	mass

Student Vocabulary Flash Cards (Page 1 - Side 2)

<p>an attraction between atoms that holds them together in a molecule or crystal</p>	<p>temperature at which a liquid changes to a gas</p>	<p>smallest piece of an element that maintains the properties of the element</p>
<p>a substance that has grown freely so that it can develop external faces, has a regular pattern</p>	<p>to change from a gas to a liquid</p>	<p>a chemical consisting of two or more elements chemically bonded together</p>
<p>a substance that can't be broken into a simpler substance by chemical means</p>	<p>to mix the molecules or atoms of one substance with another. The mixture is often called a solution</p>	<p>the amount of matter (mass) packed into a space or mass/unit volume</p>
<p>the temperature at which a liquid becomes a solid</p>	<p>to make bigger</p>	<p>to change from a liquid to a gas</p>
<p>the amount of matter in an object</p>	<p>a form of matter that has a fixed volume but no fixed shape; liquids flow!</p>	<p>a form of matter in which the molecules form no definite shape and are free to move about to uniformly fill any container; gas is fast!</p>

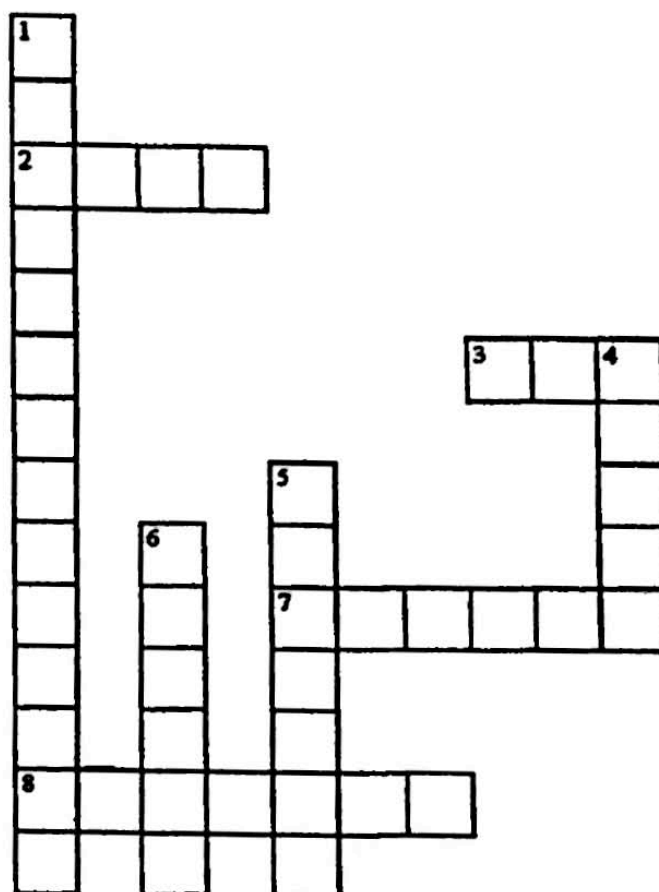
Student Vocabulary Flash Cards (Page 2 - Side 2)

matter	melting point	mer
mixture	molecule	poly
polymer	solid	states of matter
temperature	volume	water cycle

Student Vocabulary Flash Cards (Page 2 - Side 2)

<p>a repeat unit or a part</p>	<p>temperature at which a solid becomes a liquid</p>	<p>has mass and takes up space, everything is made of matter</p>
<p>many</p>	<p>a group of two or more atoms held together by chemical bonds</p>	<p>a material that can be separated into two or more substances using physical means</p>
<p>the three forms that matter may take, solid, liquid, gas</p>	<p>a rigid form of matter that maintains its shape solids slow!</p>	<p>many repeat units, a compound that is made of long chains by combining molecules (mers) as repeating units (plastics)</p>
<p>the process in which water moves through the ground, evaporates from earth into the air, forms clouds, and falls back to earth as rain or snow</p>	<p>the amount of space that an object takes up</p>	<p>degree of heat or cold</p>

Crossword



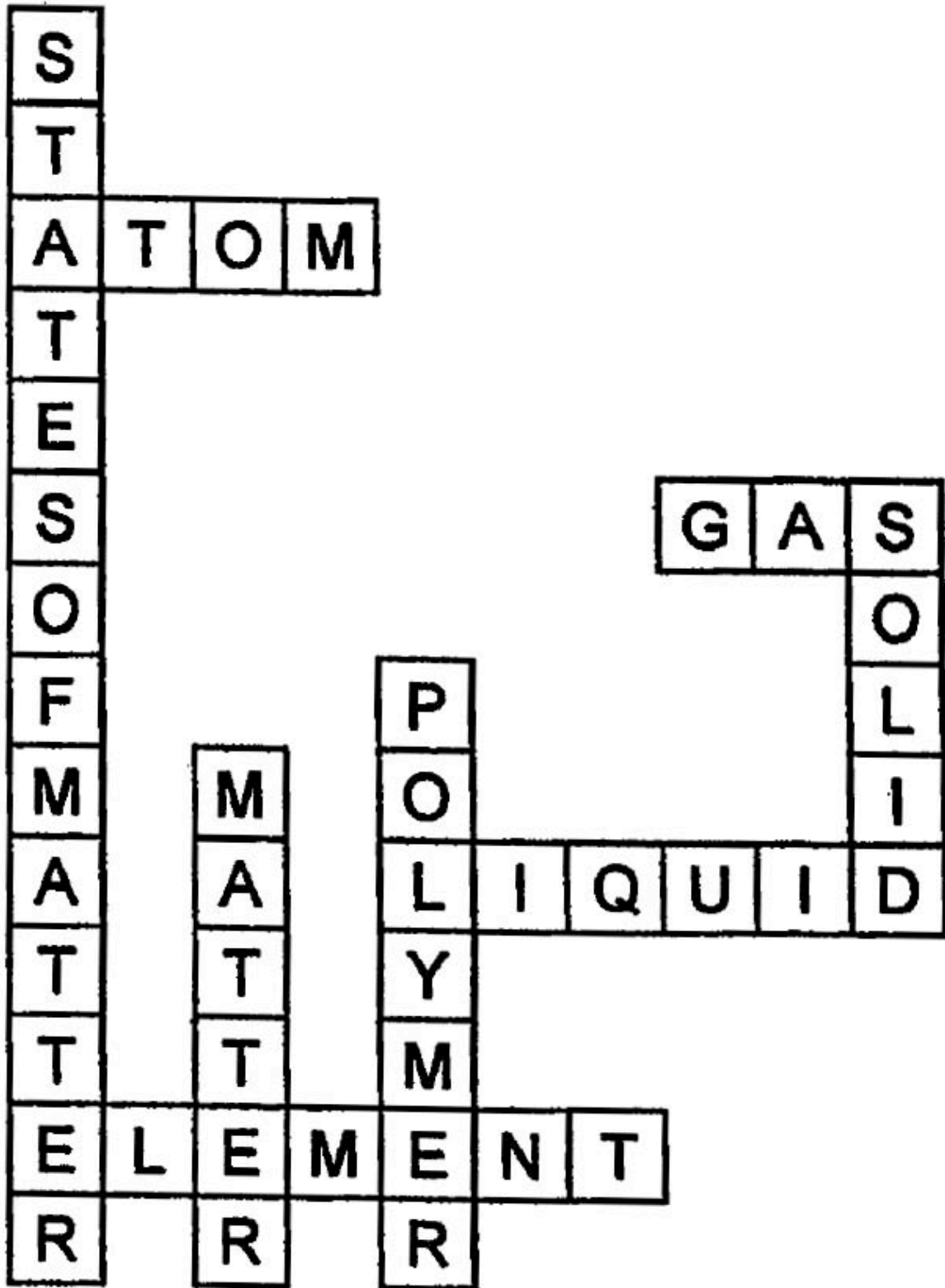
ACROSS

- 2 Smallest piece of an element
- 3 Matter in which the molecules are widely separated
- 7 Matter in which the molecules are close together and move around slowly
- 8 Can't be broken down into a simpler substance

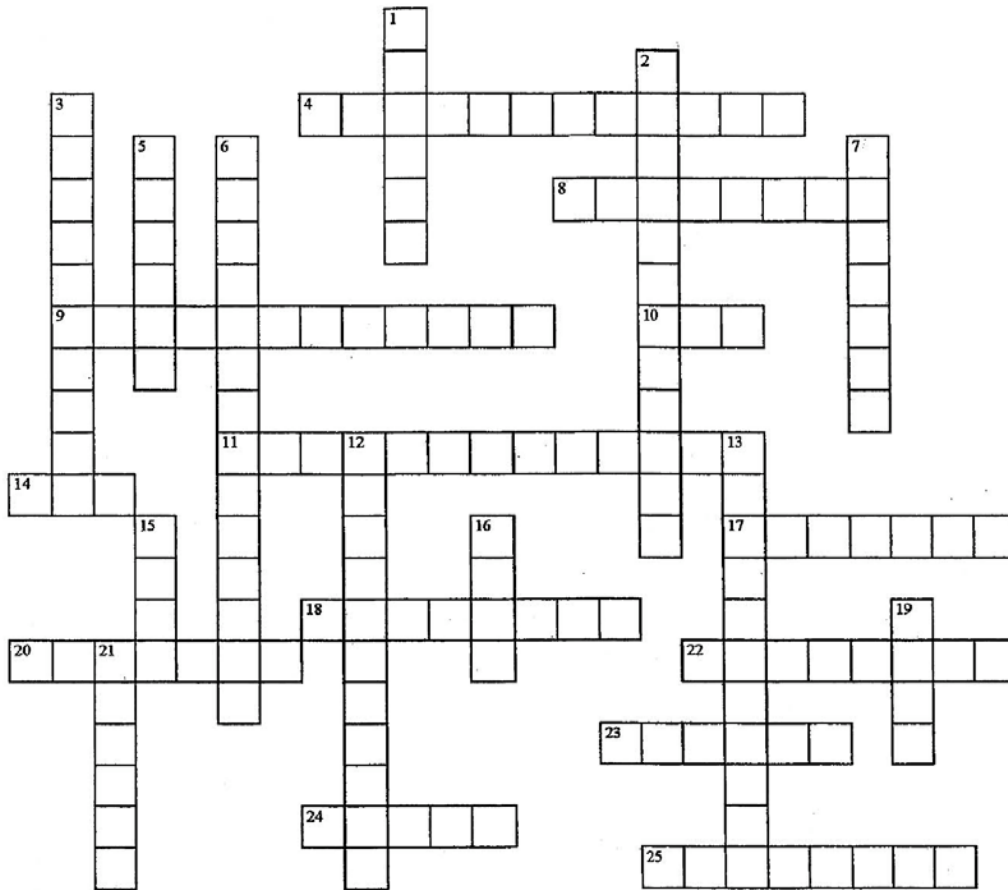
DOWN

- 1 The three forms that matter may take, solid, liquid, gas
- 4 Matter in which the molecules are very close together and cannot move around
- 5 Long chain molecules, plastic
- 6 Has mass and takes up space

Crossword Answer Key



Crossword



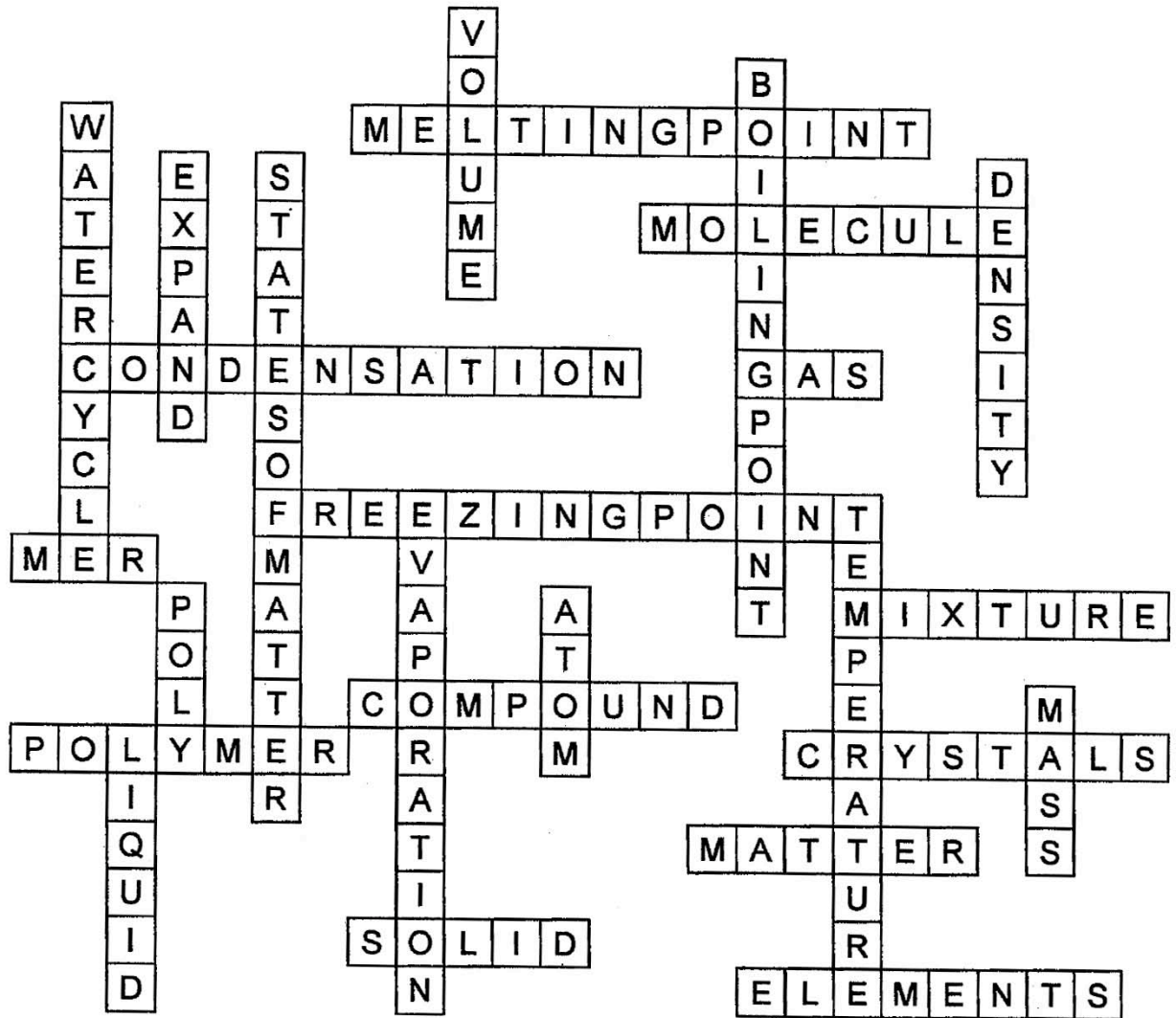
ACROSS

- 4 Temperature at which a solid becomes a liquid
- 8 Composed of two or more atoms
- 9 To change from a gas to a liquid
- 10 Matter in which the molecules are widely separated, move around freely
- 11 Temperature at which a liquid becomes a solid
- 14 Small molecule
- 17 Combination of two or more substances, each substance keeps its own property
- 18 Substance made of two or more different elements
- 20 Long chain molecules that are made by joining smaller molecules together, plastic
- 22 A solid object with shiny, flat surfaces that are arranged in a repeating pattern
- 23 Has mass and takes up space
- 24 Matter in which the molecules are very close together and cannot move around
- 25 Can't be broken down into a simpler substance, made of atoms

DOWN

- 1 The amount of space that an object takes up
- 2 Temperature at which a liquid changes to a gas
- 3 The process in which water moves through the ground, evaporates from earth into the air, forms clouds, and falls back to earth as rain or snow
- 5 To make bigger
- 6 The three forms that matter may take, solid, liquid, gas
- 7 The amount of matter packed into a space
- 12 To change from a liquid to a gas
- 13 Degree of heat or cold
- 15 Many
- 16 Smallest piece of an element that maintains the property of the element
- 19 The amount of matter in an object
- 21 Matter in which molecules are close together and move around slowly

3 – 5 Crossword Answer Key



STATES OF MATTER

What is in the bag?

1. What color is it?

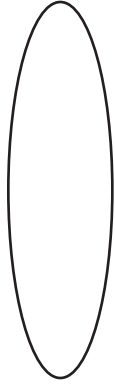
2. Is it hard?

3. Does it take up space?

4. Does it have weight?

5. Does it change its shape?

6. Does it fill the container?



TRANSFORMING MATTER

RECORD SHEET

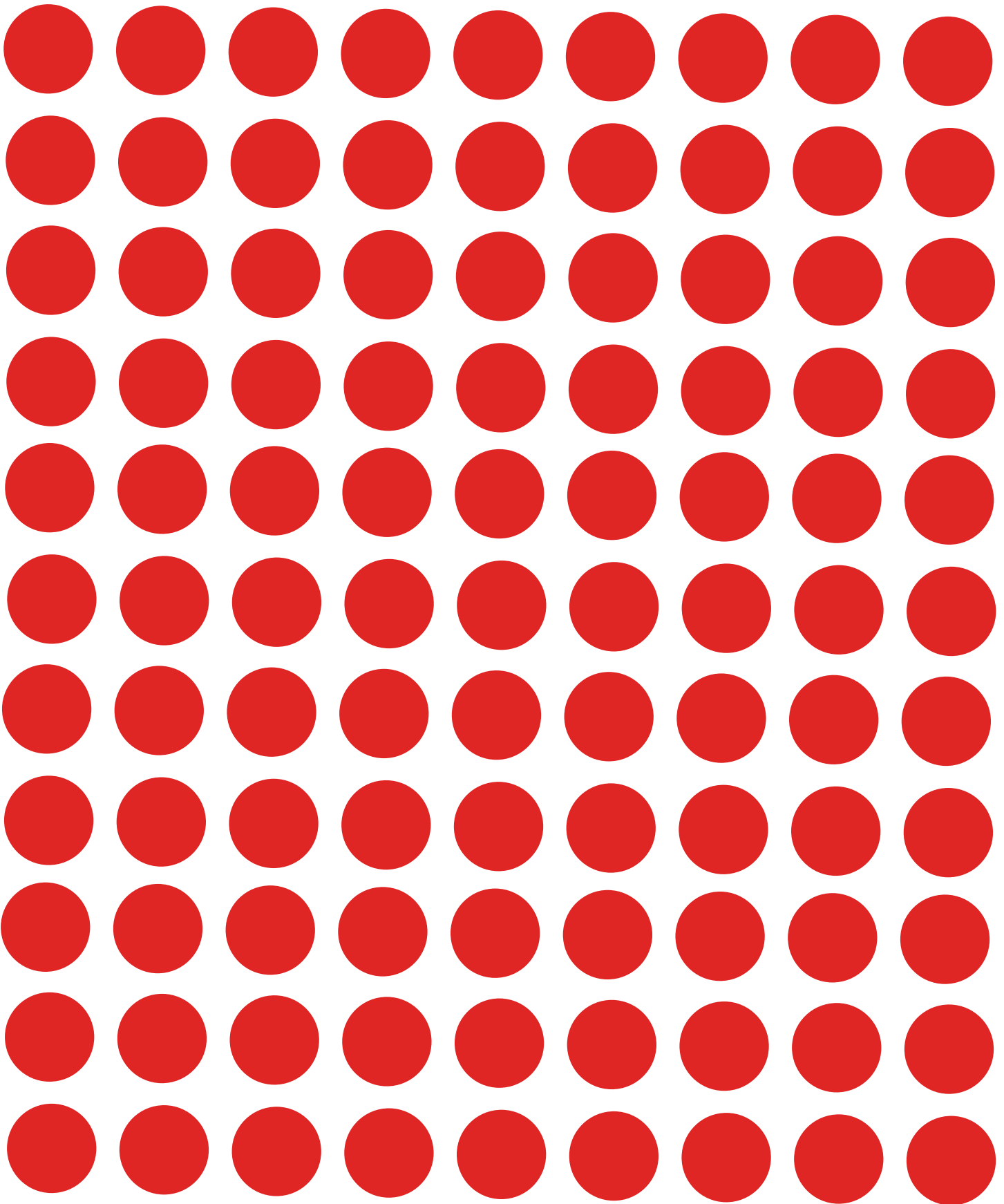
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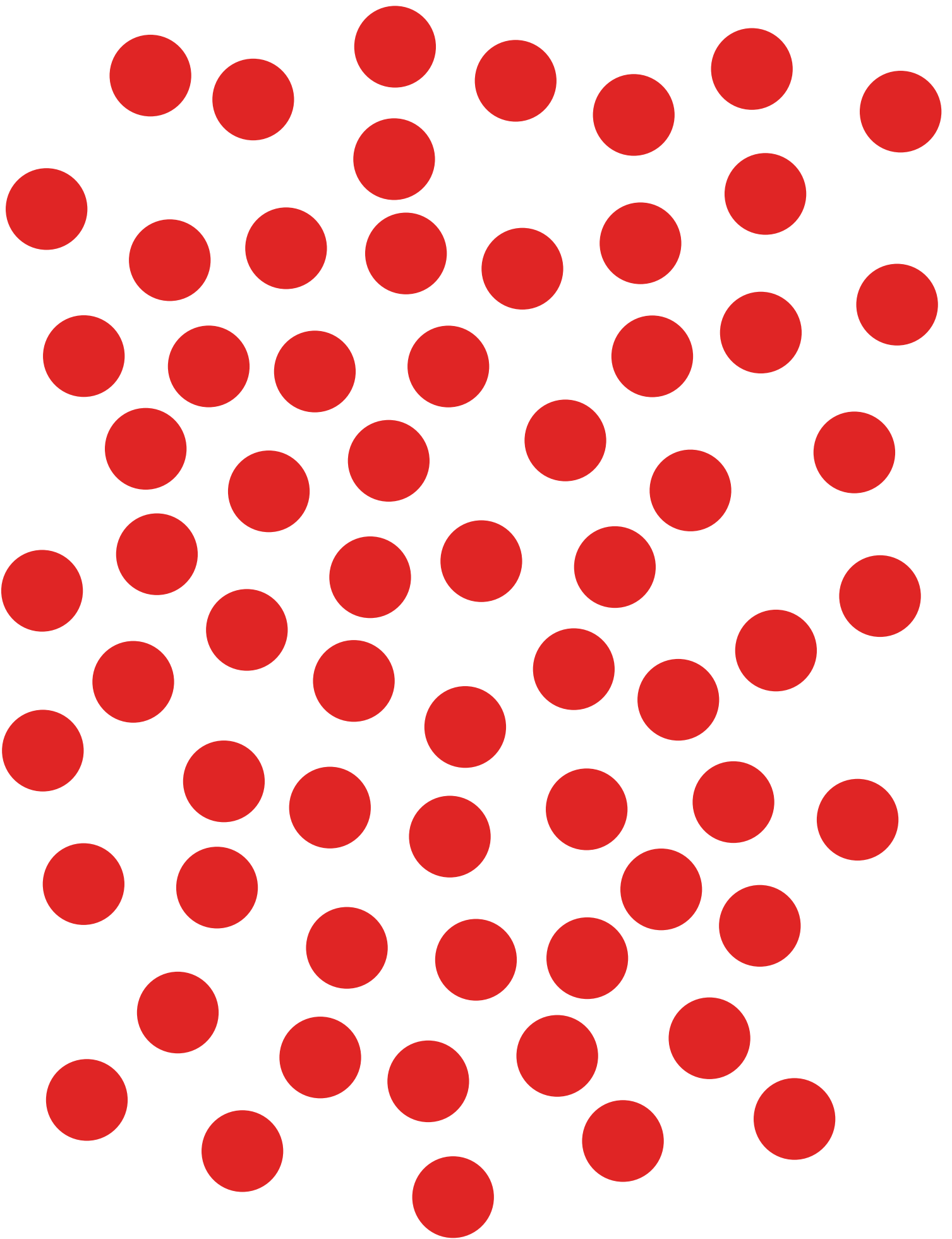
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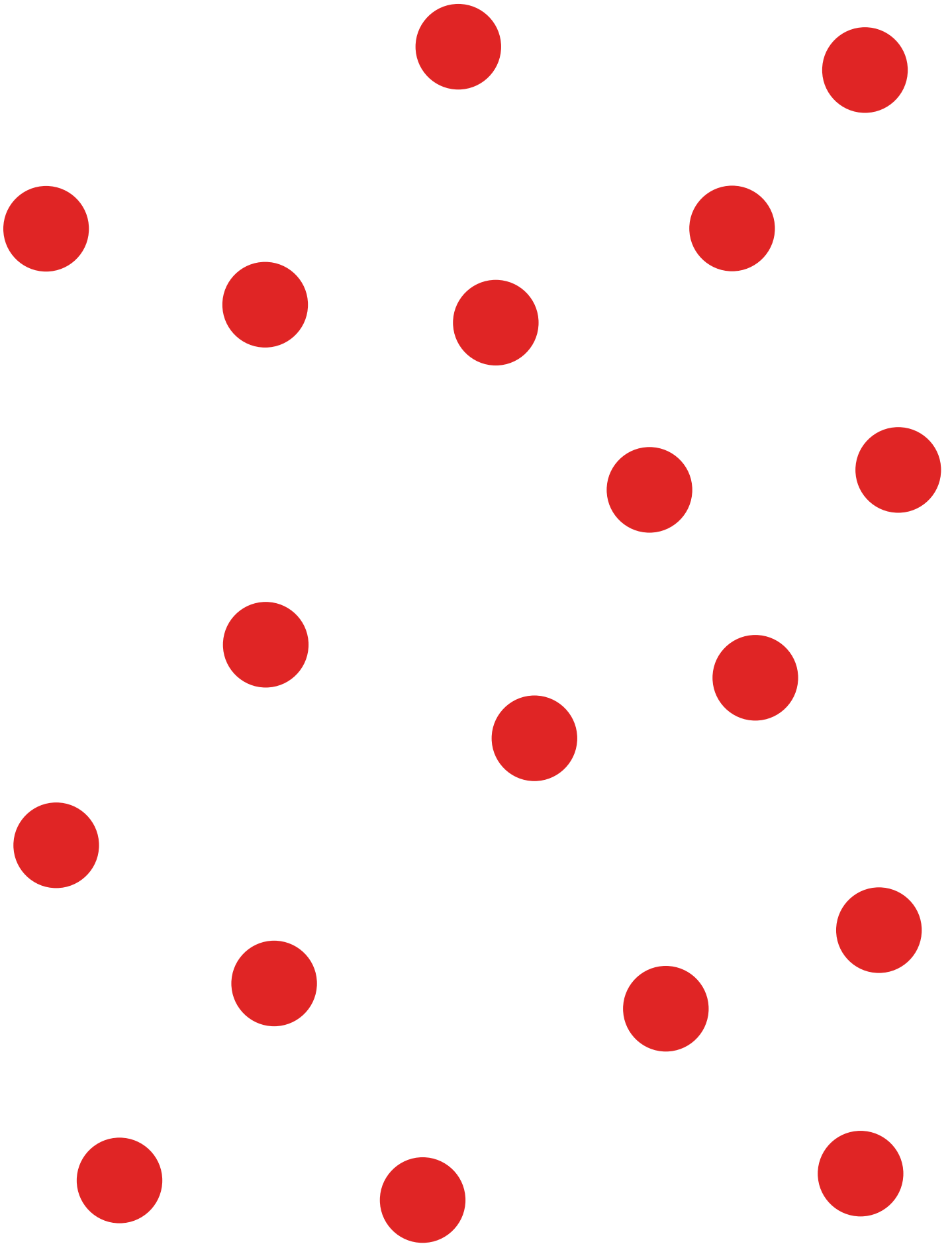
STARTING TIME	FINISHED MELTING TIME	TOTAL TIME

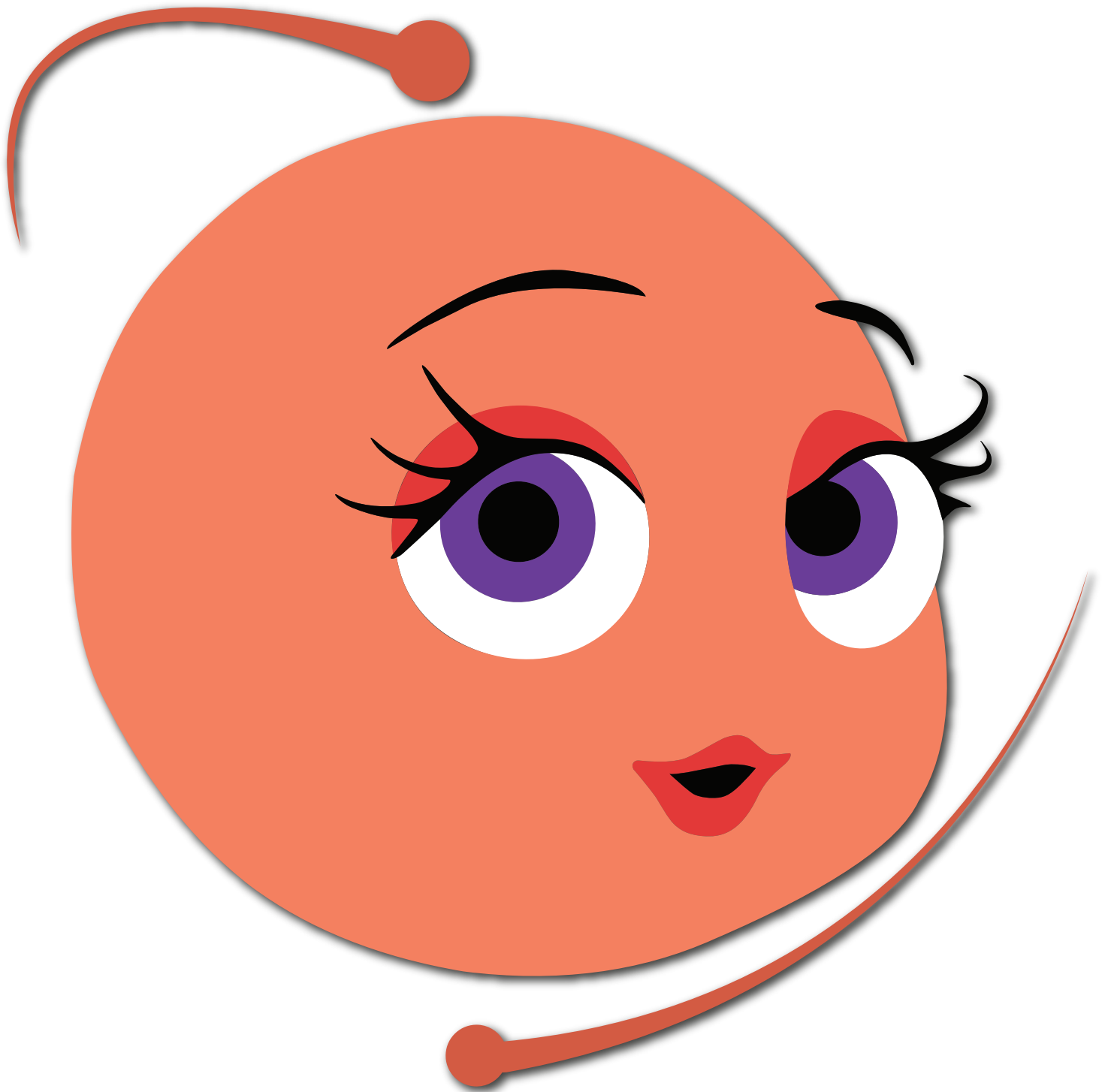
OBSERVATIONS:





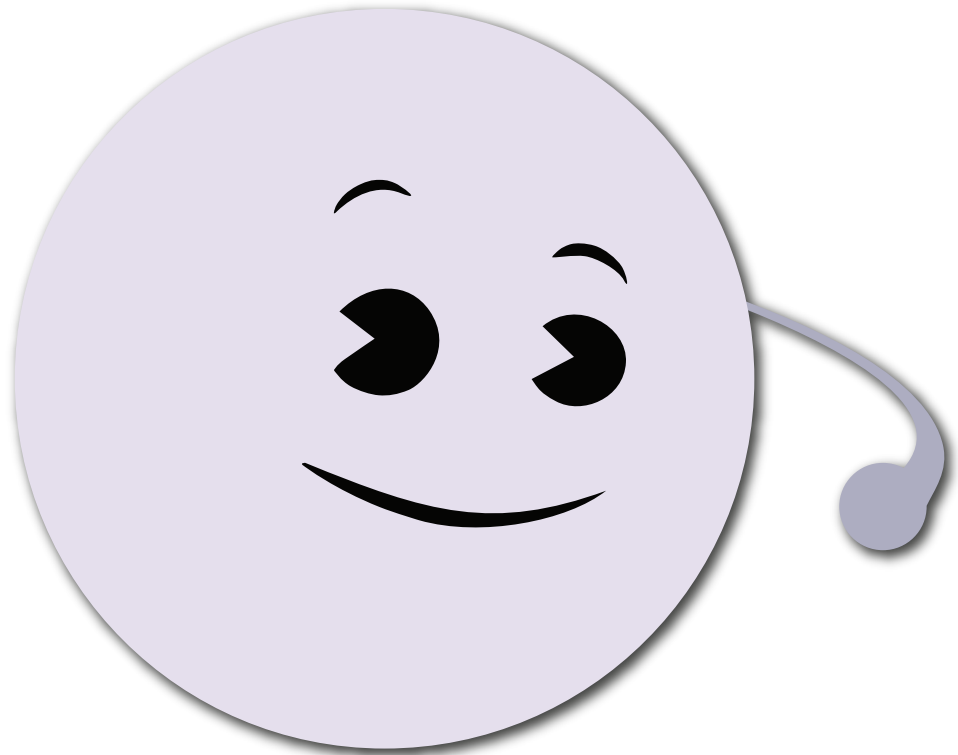






Oxy



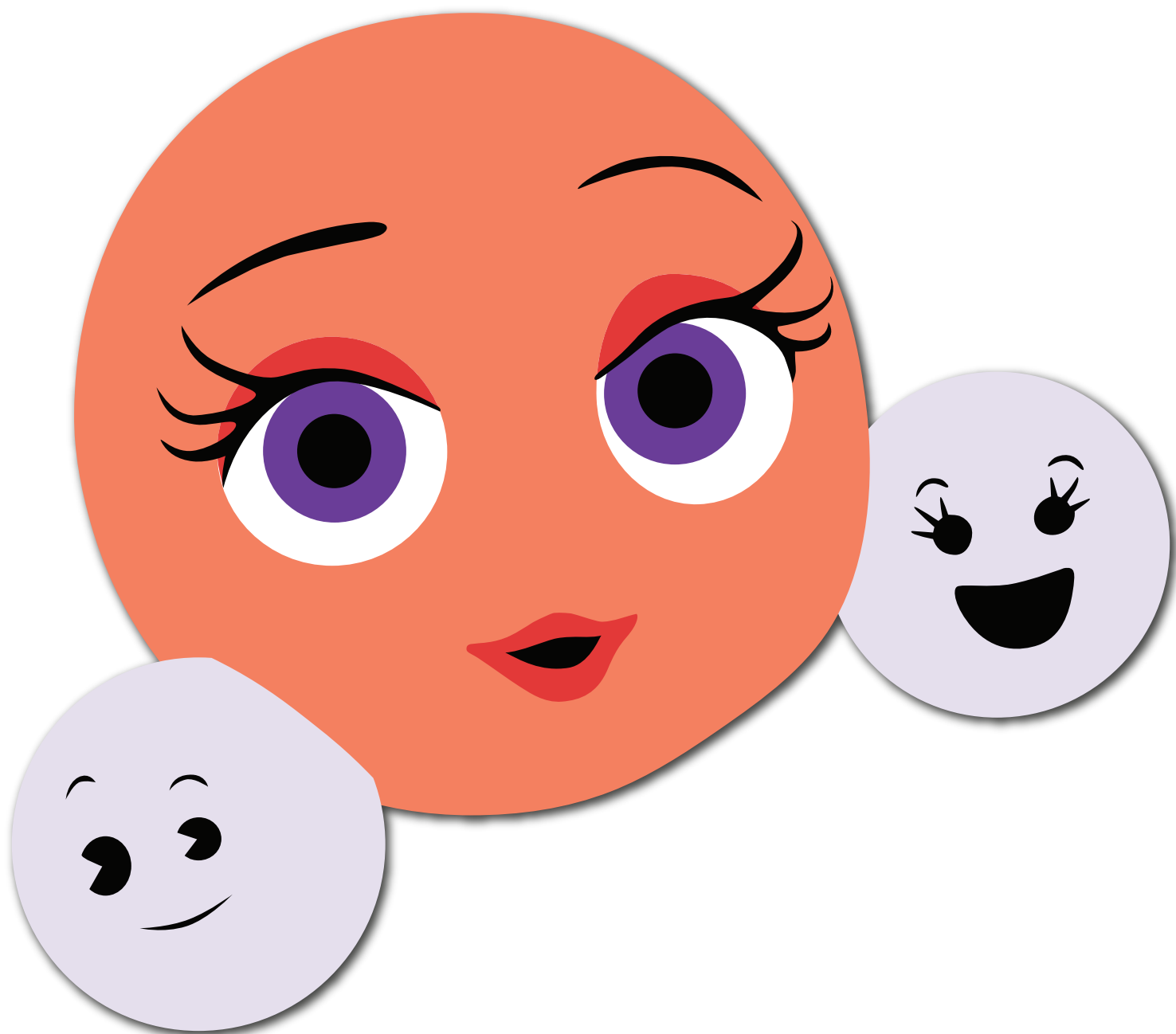


Hydro



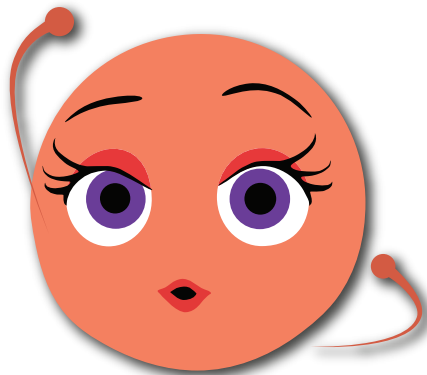
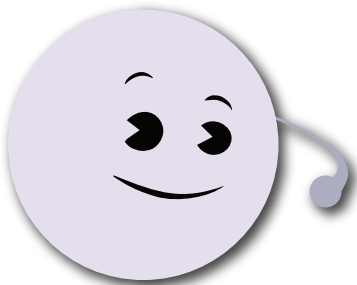
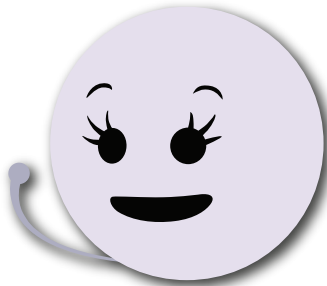
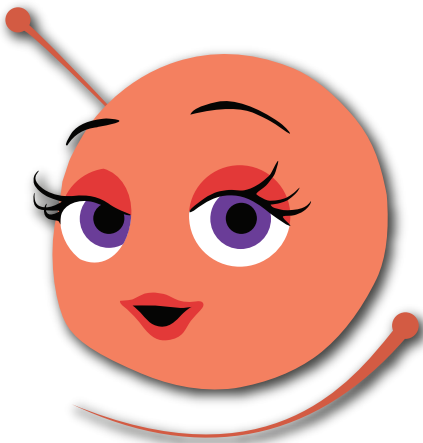
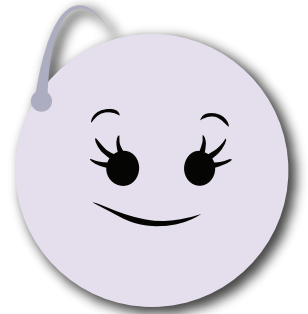
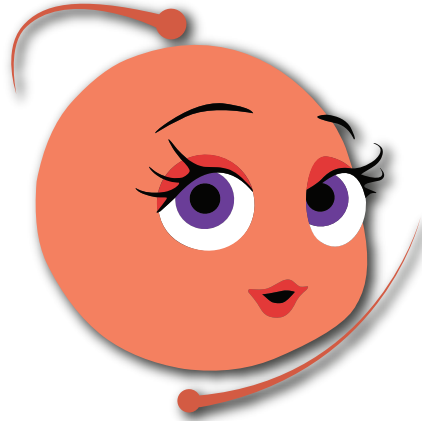
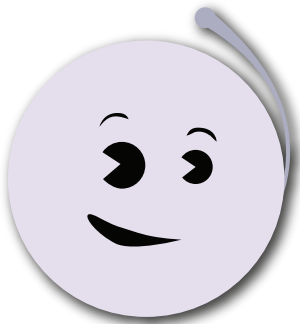
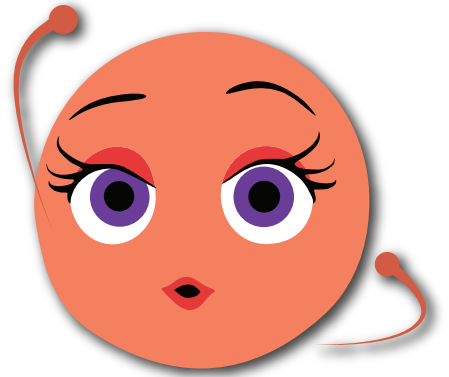
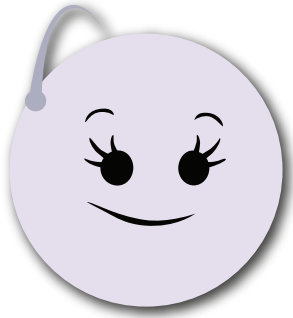
Hydra

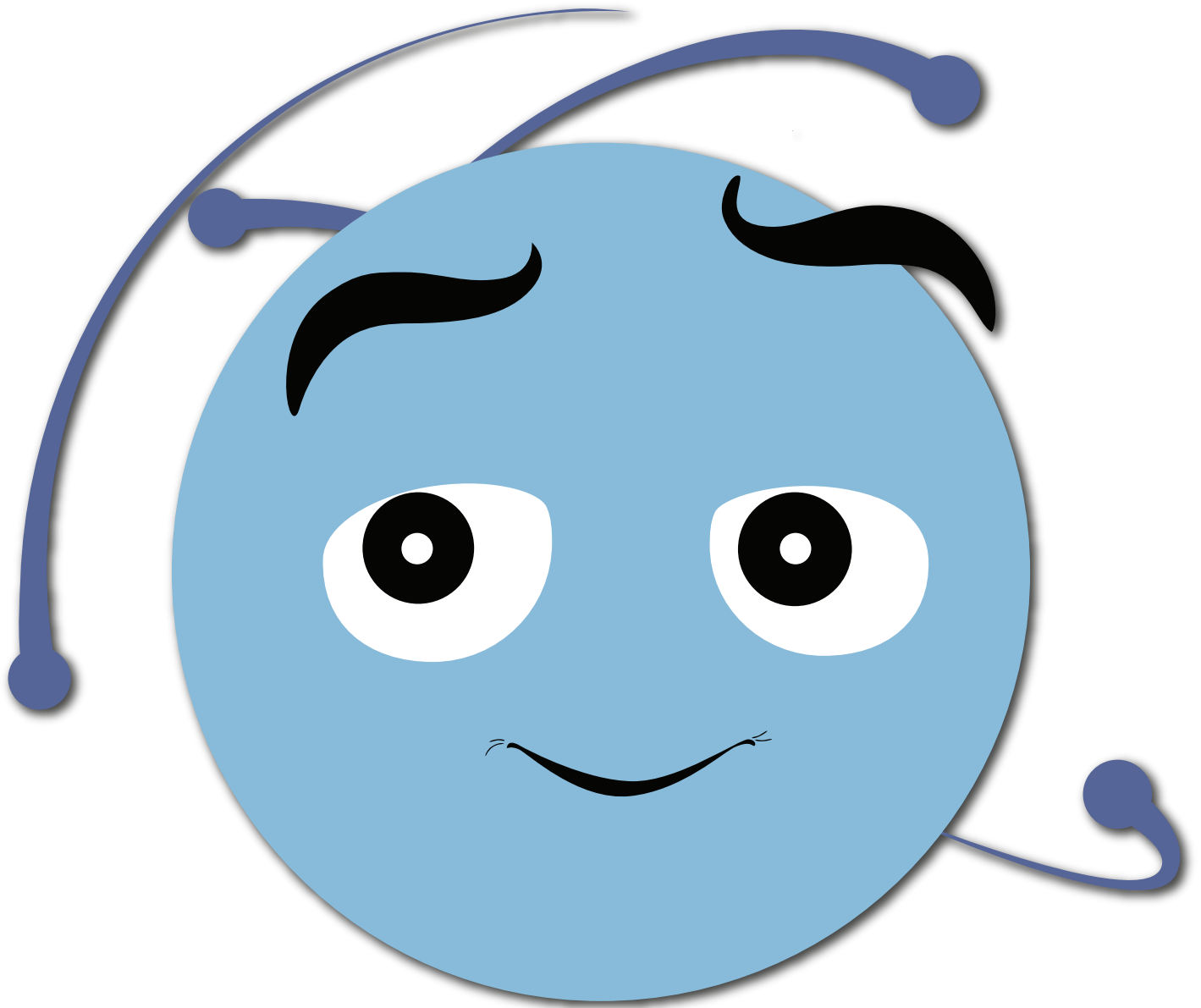




H_2O







Carbón



So Small!

**I'M SO SMALL!
HOW SMALL ARE YOU?**

**I'M SO SMALL!
HOW SMALL ARE YOU?**

**YOU CAN DRINK ME
BUT YOU CAN'T TASTE ME!**

**YOU CAN BREATHE ME
BUT YOU CAN'T SMELL ME!**

**YOU CAN FEEL ME
BUT YOU CAN'T SEE ME!**

WE ARE SO VERY SMALL-!!





H! 2! 0000H!

**I'M OXYGEN, THEY'RE HYDROGEN
WE'RE HYDROGEN!, WE'RE HYDROGEN!**

(Bond)

**WE'RE WATER! WE'RE WATER!
WE GO TOGETHER IN ANY KIND OF WEATHER
TO MAKE A MOLECULE! A WATER MOLECULE!**

(Unbond)

**WATER CLOUDS AND SNOW, THAT MEANS H₂O!
WATER CLOUDS AND SNOW, THAT MEANS H₂O!**

H! 2! 0000H!



Carbon Is Incredible!

**CARBON IS INCREDIBLE!
IT MAKES SO MANY THINGS!
FROM GRAPHITE IN YOUR PENCILS
TO DIAMOND IN YOUR RINGS!**

**THE FIRST PURE FORM IS GRAPHITE
WE MAKE YOUR PENCIL LEAD.
SO THAT YOU CAN WRITE DOWN BIG WORDS
THAT YOU'VE NEVER SAID!**

**THE NEXT PURE FORM IS DIAMOND
OH HOW THEY SPARKLE SO!
THEIR SOLID CRYSTAL STRUCTURE
IS THE STRONGEST THING WE KNOW!**

**THE NEXT PURE FORM IS FULLERENE
IT'S LIKE A SOCCER BALL!
SOME WOULD SAY THAT THEY'RE
THE SMALLEST BALLS OF ALL!**



Atoms Are Amazing!

**ATOMS ARE AMAZING!
WE MAKE EVERYTHING!**

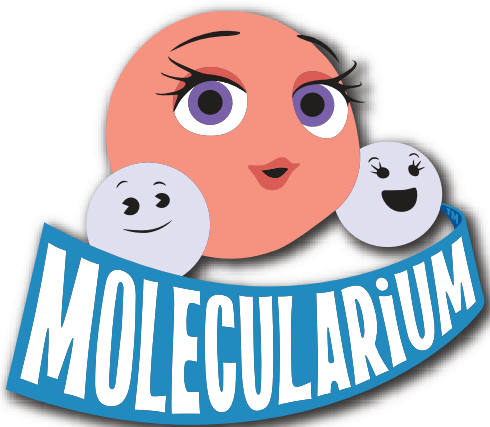
**FROM MOLECULES TO METALS
LIKE COPPER AND ZINC**

**TO POLYMERS AND PLASTICS
PENCILS, GUM, PENNIES TOO.**

**EVERYTHING IS MADE OF ATOMS!
AND MOST OF ALL ...**

**WE MAKE YOU! WE MAKE ALL OF YOU!
AND YOU TOO, AND YOU TOO, AND YOU TOO.**





What Did You Learn?

YOUR AGE _____

1. EVERYTHING IS MADE OF ATOMS AND MOLECULES YES NO

2. THERE ARE 3 STATES OF MATTER.

CIRCLE THE CORRECT ANSWER FOR EACH

SOLID **LIQUID** **GAS**

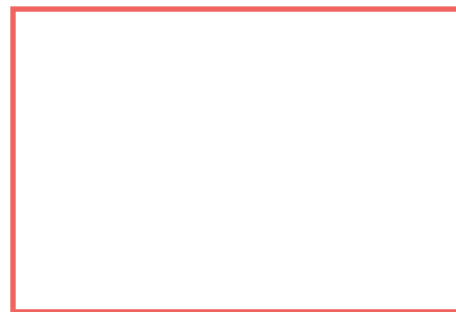
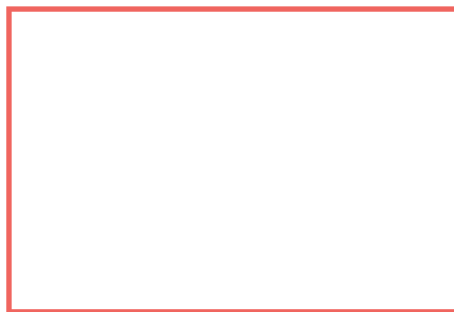
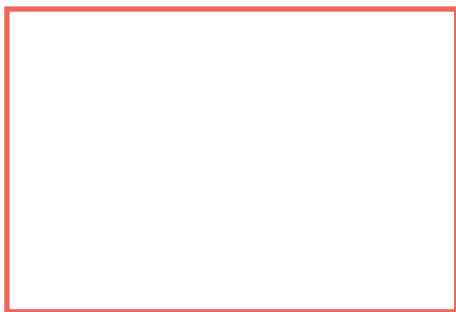
SOLID **LIQUID** **GAS**

SOLID **LIQUID** **GAS**

3. DRAW AN ATOM

DRAW A MOLECULE

DRAW A POLYMER



4. Which is **SOLID**? Which is **LIQUID**? Which is **GAS**?

SOLID?	PENNY	MILK	ROCK	WIND	SODA
LIQUID?	PENNY	MILK	ROCK	WIND	SODA
GAS?	PENNY	MILK	ROCK	WIND	SODA



5. WHAT ATOMS IS WATER MADE OF? (CIRCLE THE CORRECT ATOMS)

HYDROGEN (H) HELIUM (He) OXYGEN (O) CARBON (C) ZINC (Zn) COPPER (Cu)



What Did You Think of the Show?

DID YOU LIKE THE SHOW? (CIRCLE YES OR NO)

RATE THE SHOW ON A SCALE OF ONE TO TEN (TEN IS BEST!)

1 2 3 4 5 6 7 8 9 10

TERRIBLE

OK

FANTASTIC!

WOULD YOU SEE IT AGAIN? (CIRCLE YES OR NO)

YES

NO

WOULD YOU RECOMMEND IT TO OTHERS? (CIRCLE YES OR NO)

YES

NO

WHAT WAS YOUR FAVORITE PART OF THE SHOW? _____

