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States of Matter and Oobleck

Matter is all around us. It is a part of everything that we encounter in our day to day lives. The majority of the matter that we encounter is in the form of a solid, liquid, or gas. This lesson plan will help us understand the three states of matter, and how they differ from each other. We will then learn and observe how some different substances can change states of matter and what this does to the molecular composition of the objects. Once we have an understanding of the different states of matter, we will then explore oobleck, a non-Newtonian fluid that has properties of both a solid and liquid when different pressure is applied.

Material List

- Cornstarch
- Water
- 4 Mixing bowl
- Plastic tablecloth
- Observation worksheets
- Markers and/or crayons
- Sink
- Measuring cups
- Access to a stove
- Ice

Key Words

- Matter
- Solid
- Liquid
- Gas
- Kinetic energy
- Phase Transition
- Pressure
- Non-Newtonian fluid

Activities

1. Introduction to states of matter

Duration: 10 minutes

Link: <https://www.youtube.com/watch?v=143kDVRNVRg>

Today we are going to be learning about the different states of matter. Does anyone know what **matter** is?

- **Matter** –
 - (for younger kids) matter is the stuff around you
 - (for older kids) matter is everything that takes up space and has mass.

Do you know the different states of matter? And can you give an example for each?

- **Solid** – matter that has a definite size and shape (e.g. an apple, the table, bones, rocks)
- **Liquid** – matter that has a definite (permanent) size but not a definite shape (e.g. water, sweat, soda)
- **Gas** – matter that has no definite size and no definite shape (e.g. air, water vapor, oxygen)
 - While we can't always see gasses, they're there! And sometimes they can be dangerous for us to breathe, that's why we have things like smoke and carbon monoxide detectors

So, matter is all around us, in everything that we do! Now we are going to go on a scavenger hunt around the house for items that are solids, liquids, and gasses! How many do you think you can find?

Examples:

Solids	Liquids	Gas
Table	Household cleaners	Air (oxygen)
Computers	Shampoo	Steam (shower or stove)
Salt	Water / soda	Carbon dioxide (soda)
Pillows	Toothpaste	Carbon monoxide (from a car)
Pan/pot	Olive oil	Balloon (what's inside the balloon)

What do you notice about these different states of matter?

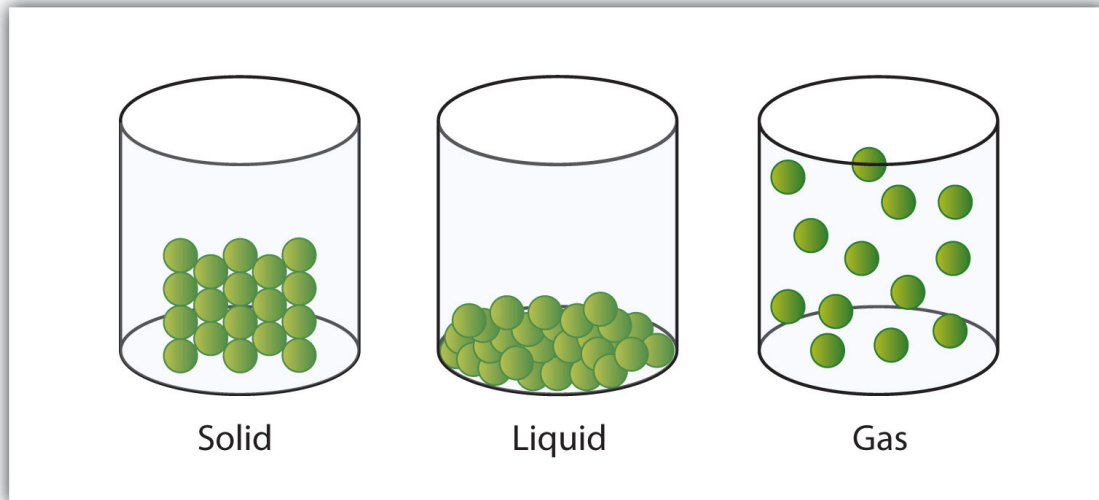
Activity 2: Changing States of Matter / Phase Transition

Duration: 15 minutes

All parts of matter are made up of molecules, and all molecules are constantly moving! They do not just sit still, and in each different state of matter, these

molecules behave differently due to their amount of **kinetic energy**—the energy that an object has due to its motion.

Using the pictures of the molecules that make up solids, liquids, and gasses, what do you notice is different between these states of matter?



How these molecules behave (and we can even act like these molecules!):

- Solid: Vibrate and do not move because they have very little kinetic energy
 - That is why solids have a fixed shape and size, their molecules are packed too tightly they do not move, only vibrate
 - How to act like molecule in a solid: your feet stay in place, but your body shakes or vibrates
- Liquid: Vibrate and slide past each other due to some kinetic energy
 - The molecules have enough kinetic energy to slide past each other, but not completely pull apart, which is why a liquid can change shape but has a fixed volume (why 100mL in a large bowl = 100mL in medium bowl)
 - How to act like molecule in a liquid: slowly glide around
- Gas: Vibrate and move freely at high speeds because the molecules have lots of kinetic energy
 - Due the large amounts of kinetic energy in gasses, the molecules can pull apart and can move freely, this is why they do not have a fixed shape.
 - How to act like molecule in a gas: quickly move around freely

Some substances can change states of matter because of a change in the kinetic energy in their molecules. For example, water can be a solid (ice), liquid (water), and a gas (steam/water vapor).

- How does a liquid like water change states of matter? (Temperature)

With adult assistance we can observe these changes of states of matter

Procedure:

1. Place ice cubes in a pot on a low heat
2. Once the ice melts, fill a pot with more water and bring to a boil
3. Cover with a lid (preferably clear)
4. Observe and write down observations on worksheet

Explanation:

We start with ice (a solid), as the pot warms up, the ice melts and becomes water (a liquid). When the water is heated, it evaporates, and becomes a gas. Once it reaches the lid of the pot, it cools (condenses) and becomes a liquid again, which is why we see little water droplets on the lid of the pot.

You can also do this without a lid on the pot and observe the steam rise from the pot.

This is called **phase transition**, when a change of state occurs at a specific temperature.

- Water turns to ice at 32°F (0°C) and evaporates at 212°F (100°C).

Activity 3: Oobleck

Duration: 15-20 minutes

Link: https://www.youtube.com/watch?v=3qnC_R1Kn_I

Disclaimer: this can get messy! It is easy to wash off, but you may want to put something down to protect your surfaces (newspaper, rags)!

Disclaimer at the beginning of the video about mess. Put things down on table

So far, we have worked under the assumption that all solids, liquids, and gasses always act in the same way. However, this is not true for all matter.

We are going to make oobleck, a substance that can be like a solid or liquid depending on how you interact with it.

The two materials that we need are cornstarch (a solid—very small solids) and water (a liquid).

Oobleck is an example of a **non-Newtonian fluid** (substances that do not behave the way you think they will). Every substance has a property known as **viscosity** — the rate at which a fluid flows (“drips” for younger children). Newtonian, or

“normal” fluids flow at a constant rate. But depending on how much force or **pressure** is applied to non-Newtonian fluids, their viscosity changes. We can see this when we play with the oobleck.

Procedure

1. Pour 2 cups of cornstarch into a tray
2. Slowly pour in 1 cup water, mixing slowly as you go until consistency is similar to that of honey.
3. Oobleck is done when it is no longer powdery (needs more water) but doesn't splash when hit with a spoon (needs more corn starch)

Once the oobleck is made, before we start to interact with it, do you have any predictions of how it will behave?

Observation worksheet questions:

- What happens when we hold the oobleck and squeeze it tightly in a ball?
- What happens when we pick up the oobleck and leave it in our hands without applying any pressure?
- What happens when we hit the oobleck? Does it react like a solid and hold its form or does it splash like a liquid?
- What happens when we place our hand on top of the oobleck with very little pressure? Does our hand stay on top of the oobleck? Does it slowly go into the oobleck?

Why does this happen?

Non-Newtonian fluids behave like solids for a short time, and then over the longer time, they behave like liquids.

The cornstarch molecules are very small, but they are solids. When a sudden force is applied to oobleck, the starch grains rub against each other and behave like a solid. When you apply slow pressure to the oobleck, water droplets surround the cornstarch particles, allowing the cornstarch particles to be surrounded by water molecules and behave like a liquid. Water acts as a liquid cushion or lubricant, allowing the grains to flow freely.



Why does this happen with cornstarch?

Cornstarch particles are very very small (thinner than your hair) and they repel water, therefore they do not dissolve in the water.

Conclusion

Today we have learned about the three states of matter: solids, liquids, and gasses, and about the different ways that molecules act in different states of matter due to the differing amounts of kinetic energy in the molecules. We have also learned about some types of matter that do not fit into a clear category of solids, liquids, or gases, which we call non-Newtonian fluids and that these substances react differently based on the different forces of pressure applied to them. Finally, we have experienced how these substances are both solid and liquid. I hope everyone had fun learning about matter!

Instructor Comments

For the end of the lesson, allow time for children to clean up from the oobleck. To dispose of the oobleck, simply rinse the containers with lots of water. Include that this washes off easily, as it is just cornstarch and water if some children are hesitant to touch it.