

# How Squishable?

**Key Question:** How are solids, liquids, and gases different from each other? What makes them different from each other?

**Draw:** In each box below, **make a drawing** to show how particles might be spaced if you could take a picture of them and greatly magnify them. How would they be spaced in a *solid*? in a *liquid*? in a *gas*? In your pictures, make each particle about as big as this circle: ●

SOLID	LIQUID	GAS

**Get this:** You need a **syringe** and a small **drinking cup**.

**IMPORTANT:** Every person in your group must push the syringe for himself/herself.

It is important that everyone gets to feel the forces and movement of the plunger in every step. You cannot simply let your lab partners tell you how it feels; you need to feel it for yourself every time.

## Step 1: AIR in the Syringe

- Open the nozzle and **let some air into the syringe** by pulling the plunger back.
- Now **plug the nozzle** tightly so air cannot escape. There are two ways you can plug it:
  - Plug it tightly with your thumb, or
  - press it down against a large flat eraser on the table.
- Now, with the nozzle tightly plugged, try **pushing** the plunger in as far as you can.
- Make sure every member of your group gets to push the plunger and feel the forces.

**Observations:** Write down what you observed and felt when you pushed the plunger.  
Make sure all members of your group agree on what you observed and felt.

## Step 3: WATER in the Syringe

- Open the nozzle and push the plunger all the way to **push out all of the air**. (Empty the syringe.)
- While the syringe is empty, hold the nozzle downward in a cup of water (see the upper picture), and then pull the plunger back to suck up the water to the **30 mL** mark.
- Get out all remaining air bubbles. Here is how: Over a sink or tub, hold the syringe vertically with the tip up. Tap it lightly to dislodge any air bubbles, and then **slowly** push in the plunger until all the air is expelled and a few drops of water squirt out. (See the lower picture.)
- Now **plug the nozzle** tightly so water cannot escape. (Plug it with your thumb, or plug it by pressing it down against a large flat eraser on the table.)
- With the nozzle tightly plugged, try **pushing** the plunger in as far as you can.
- Make sure every member of your group gets to pull and push the plunger and feel the forces.




**Observations:** Write down what you observed and felt when you pulled and pushed the plunger.  
Make sure all members of your group agree on what you observed and felt.

**Step 4: SOLID PELLETS in the Syringe**

For this step, you need a new syringe that is already half-full of red plastic pellets. These pellets represent a solid. Do NOT pull back on the plunger (so that you do not spill any pellets).

- a) Plug the nozzle tightly so the pellets and the air cannot escape.
- b) Now, with the nozzle tightly plugged, try *pushing* the plunger in as far as you can.
- c) Make sure every member of your group gets to push the plunger and feel the forces.

**Observations:** Write down what you observed and felt when you pushed the plunger.  
Make sure all members of your group agree on what you observed and felt.

**Redraw:** Based on what you have just done, make a new drawing to show how particles might be spaced if you could take a picture of them and greatly magnify them. How would they be spaced in a *solid*? in a *liquid*? in a *gas*? In your pictures, make each particle about as big as this circle: 

SOLID	LIQUID	GAS

**Follow-Up Question:**

See again your results for Step 3. You filled the syringe with some water, plugged the nozzle, and tried to push the plunger in. Why was it so hard to push? What does this idea tell you about the particles in a liquid—how close together are they?

# TEACHER NOTES

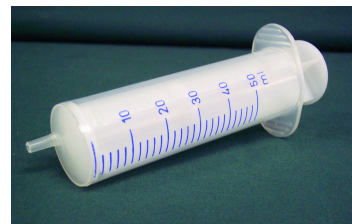
## Intended Learning Outcomes

Students will understand the following:

- Solids, liquids, and gases are made of particles.
- Gases are noticeably compressible, but solids and liquids are not.
- The reason a gas is compressible is that there is a significant amount of empty space between the gas particles (the particles are spread out from each other).
- The reason liquids and solids are not compressible is that the particles are essentially already as close to each other as they can be (we may picture them as bundled together, touching each other).
- Particles in a liquid are as close together as they are in a solid.
- The key difference between solids and liquids is the *freedom of particles to move*, not the amount of spacing between the particles. Particles in a liquid have no particular arrangement; they are free to move around each other. Particles in a solid are not free to move around each other—they are “stuck in place”, usually in some type of organized pattern.

## Supplies

- one syringe per group, extra large; 60 mL is an ideal size.  
(These can be purchased at many veterinary/livestock supply stores.)
- one cup per group, for holding water  
(at least as much volume as the syringe)
- large rectangular eraser per group, or other piece of hard rubber  
(some students may want to press the syringe against it)
- another large syringe per group, already filled with small plastic pellets  
(plastic pellets = plastic BB's, found at many sporting good stores)



## Student's Prior Knowledge & Experience

Student should have completed several activities so far, including “**Swab the Deck**”, “**Drops on a Candle**”, and “**Nosey Balloon**”. They may have also completed the activity “**Mixing Liquids**”.

By now students should know the basic theme of this unit—that we have proposed the following “model” about matter, and we are continuing to look for evidence to test it and build it further. Here is a way to organize the model so far:

### **PARTICLE MODEL of MATTER**

**Everything in the world is made of tiny particles.**

**Some properties of these particles:**

#### **STICKINESS:**

**All particles show some amount of “stickiness” – they cling to each other and to other things.**

**The amount of stickiness varies. Some particles stick to each other very strongly; others stick less strongly. But all of them are sticky.**

#### **SPACING:**

**The particles in a substance can have tiny pockets of empty space between them.**

Today's activity, "How Squishable?", should help students continue the idea of spacing and arrangement by adding these points to the model:

**Solids, liquids, and gases are all made of particles.**

**More about SPACING:**

**In a gas, there is a lot of empty space between the particles (they are spread out).**

**The particles in a liquid are as close together as they are in a solid.**

**The particles in a solid are locked in place; the particles in a liquid are essentially touching but are free to move around each other.**

## Class Time Needed

**15 to 25 minutes** for small groups to do the procedures and complete the questions.

**10 minutes** minimum for the whole-class discussion after the activity. There are two optional follow-up activities/demonstrations that can add 15 to 25 additional minutes to this discussion.

## Lesson Outline and Teaching Suggestions

### Introducing the activity

Remind students of the theme of the unit, the "**Particle Model of Matter**". It should be displayed somewhere for students to see. (The model ideas can be found in the section above, "Student's Prior Knowledge & Experience".)

The purpose of today's activity, "**How Squishable**", is to explore an important property of solids, liquids, and gases—how much you can squeeze them. This property will tell us something important about the particles they are made of.

**Engage:** Before students start working with any equipment, have them do the beginning section called "**Draw**".

- You might need to read the instructions out loud for them. Make sure they understand the instructions, but don't tell them what their drawings should end up looking like!
- These drawings will be guesswork for most students; they should not already "know the answer." Reassure them that it is perfectly OK to be wrong, as long as they give it their best try.
- Instruct students to do the drawings individually, not in groups; they will think harder and learn more. After they finish drawing, you can have them share their pictures with each other (but tell them not to change their drawings just because they saw another student's drawing).

**Explore:** When the class is ready to get some equipment, make sure they understand a few basics before they start working:

- Students should not go back and change their drawings, even if they think their drawings are wrong.
- In several steps the lab directions instruct students to cap the opening of the syringe and push the plunger. Students can cap it with their thumb, or they can cap it with a rubber eraser (or other piece of hard rubber). If they use the eraser or hard rubber, they can cap it, turn it upside down, and press it against the table. Some students find this method easier to apply a lot of pressure without leaking any contents. (But you will get dents in the erasers!)
- Every student in every group should push the plunger every time. No student gets to "sit back and watch" – everyone writes down what he/she felt, not what his/her partner felt.
- When students get to Step 4, they should come to the teacher and trade in their empty syringe for another that the teacher has already pre-filled with pellets.
- In Step 4, students should NOT pull back on the plunger. You do not want pellets coming out and falling all over the classroom floor!
- At the end of the activity is a chance to "**redraw**" the particles in a solid, a liquid, and a gas. If students changed their ideas about how to draw the particles, here is where they can show it.

## During the activity (students working in small groups)

Make sure every member of every group is pushing the plunger every time.

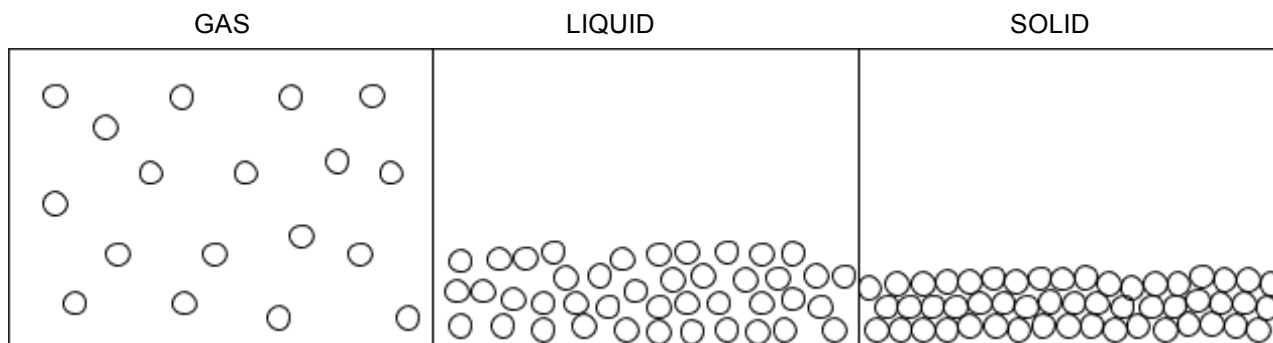
If some students have a hard time capping the syringe tip with their thumb or finger, they can press it down against an eraser or hard piece of rubber, as shown at the right.



## Explain: Whole-class discussion after the activity

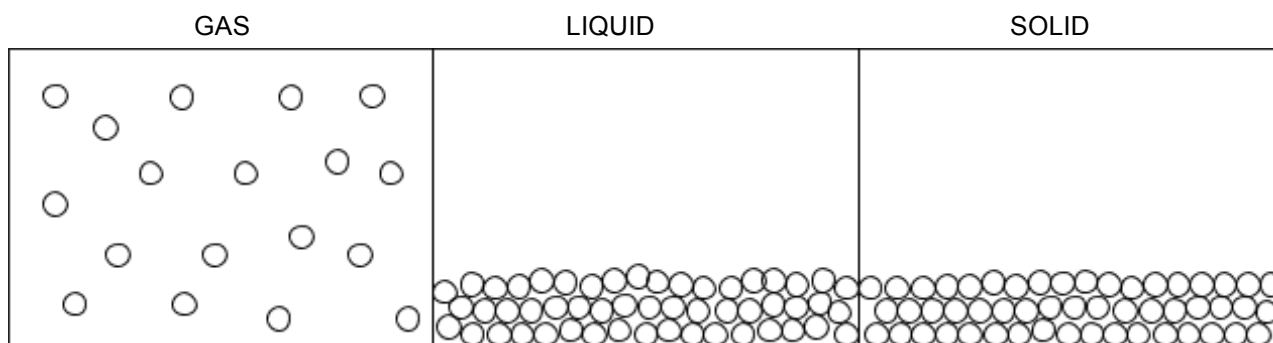
Ask students to describe what they drew at the beginning of the lab and at the end of the lab.

Here are some examples of what students will sometimes draw in the “**Draw**” section, before using the syringes:



Sometimes students will completely fill up all three boxes with circles—from the bottom of the box to the top of the box. Usually most students show the liquid particles spaced near each other but not touching, and they show the solid particles all touching. Some students organize the solid particles in neat rows and columns. Since these drawings are all guesses, anything thoughtful is OK.

Here are the most common drawings at the end of the activity, in the “**Redraw**” section:



Students find that the liquid is not noticeably compressible, and they realize that the particles must be packed close enough to be touching, or nearly touching. Some will be reluctant to draw them as closely packed as in a solid, because it simply does not “feel correct”—they know solids must be special in some way, but they aren’t sure what that special way is. Usually students will either (1) try to pack them more tightly in the solid or (2) show some type of organization in the solid.

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## Follow-up: Two analogies

The following two ideas are recommendations for what to do next. These ideas can help students picture that liquid particles are essentially about as close together as solids, but they are simply not locked into position as they are in a solid.

### 1. Lego analogy:

- (a) Break the class up into groups of 2 to 4 students. Give each group at least 6 Lego blocks. Best Legos to use: “Duplo” size (fairly large); use short rectangles that are all about the same size as each other. (Lego squares are not as good as Lego rectangles.)
- (b) Tell students that each Lego block will represent a particle of a substance like water. First, tell students to make their blocks represent solid water, which is ice. Don't tell them how to arrange the Legos (don't tell them to lock the Legos together); let them figure it out themselves. Walk around the room and check that they are locking all the Legos together. If some groups don't lock them together, show the group that unlocked blocks can “flow” and move around each other, which is not the way a solid behaves.
- (c) Next, tell student to make their blocks represent a liquid, such as ordinary liquid water. Walk around and see that they are unlocking the blocks but keeping them pressed up against each other. If students try to leave some space between the blocks, ask them what would happen if you tried to squeeze their “liquid” in a syringe, like they did in today's experiment. It should show no compressibility – which means the blocks must be already touching just not locked in place. There should be no empty space between blocks.
- (d) Finally, ask students to represent a gas, such as steam. Walk around and check – students should have the blocks spread a fair distance apart from each other.
- (e) Finish by asking the class to give you the key differences between a solid and a liquid. The difference is not spacing; the difference is that particles are *locked into place in a solid; in a liquid, they are touching, but they are free to move around each other, which is why liquids can flow.*



## 2. Ping-pong ball analogy:

You need some time before class to prepare this demonstration.

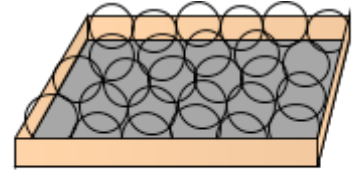
- Materials:**
- Large quantity of ping-pong balls, small Styrofoam balls, or other uniform-sized balls.
  - Two clear (see-through) containers; each one should be able to hold 20 to 50 of the balls.
  - Large shallow pan or box that can hold 20 to 50 of the balls. Determine how many balls will fill the bottom of this box in a single layer without empty space between the balls.

**Preparation:** Glue a bunch of these balls together into a 3-dimensional shape that fits into the clear container—a cube that is 3x3x3 balls, for example. As much as possible, organize the stack of balls into rows and columns as you glue them. Use some strong glue, and give it time to dry.

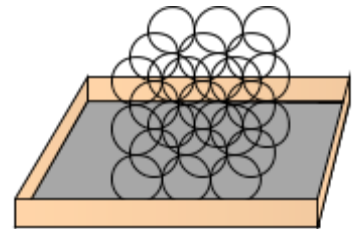


### The demonstration:

- Have the shallow box sitting on your table top. Also have the two clear containers ready—one of them is filled with unglued ping-pong balls, and the other is filled with the glued pack of balls.
- Show the students the container of unglued balls. Pour these balls into the shallow box. Notice that the balls “flow” and fill the shape of the shallow box; they can flow and move around each other and change their arrangement, but they don’t need to spread apart from each other. This is a liquid. When you are done showing this, pour them back into the clear container.
- Now show the glued balls in the other clear container. Try pouring them into the shallow box. The whole lump should simply fall into the shallow box without spreading out or changing shape. This is a solid.



*unglued balls —  
after pouring into the shallow box*



*glued balls —  
after pouring into the shallow box*

### Notebooking Essences used:

**Prior Knowledge-Draw models of solids, liquids, gases**

**Data Collection-**

**Sense Making-Explain and draw models**

**Metacognition-Revise models and explanations**

**Crosscutting: Energy and Matter  
Cause and Effect**

**S and E Practices: Developing and Using Models  
Constructing Explanations**