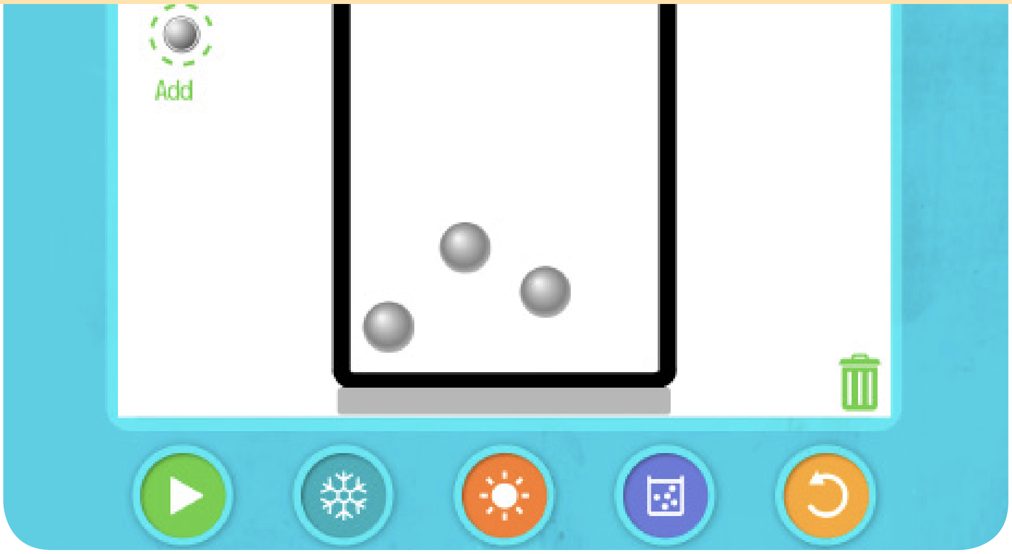
The Particle Modeler

Get ready to play with the submicroscopic world! The Particle Modeler is a playground for experimenting with the building blocks of matter. Drag particles around, then see how they move.



Getting to Know the App

The Particle Modeler provides a look inside matter. It gives children a chance to see what particles do when things get hotter or colder. When things get hotter, particles move faster. Particles bump into each other more often and may change from being clustered close together as a solid to flowing around each other as a liquid. With another rise in temperature, the particles fly around to fill the volume of a container as a gas. The change of state can also happen in reverse when the temperature is reduced so that fast gas particles slow to liquid particles. As the temperature is further decreased, the particles just wiggle in one place as a solid. In all cases the particles in this modeler conform to the laws of physics, including the way slow particles are pulled downward by gravity or how adjacent particles are mildly attracted to each other.

What it Teaches

The Particle Modeler reframes temperature as the speed of particles, rather than the common misconception that temperature increases by adding more hot "stuff." By watching the particles increase their speed when the child taps the sun icon at the bottom of screen, the child will learn that heating a material increases the speed of its particles. Conversely, when watching the particles reduce their speed when the child taps the snowflake icon, they learn that the same material can change speed (temperature) in both directions.

With additional changes in temperature, the particles change states of matter in both directions (e.g., evaporation one way, condensation the other way).

The Particle Modeler is designed to teach the following concepts:

- Gas particles fly throughout a container.
- Solid particles cluster together but wiggle in place and maintain their arrangement.
- Liquid particles flow around each other but stay close together.
- Increasing the temperature does not always change the state of matter.
- Particles bump off each other more vigorously if they are moving fast.
- Fast particles bump the sides of a container more often than slow particles.
- Liquid particles do not fill up the volume of a container.
- To prevent gas particles from leaving a container the container needs a lid.
- Fast particles can bump and separate a cluster of slow particles.

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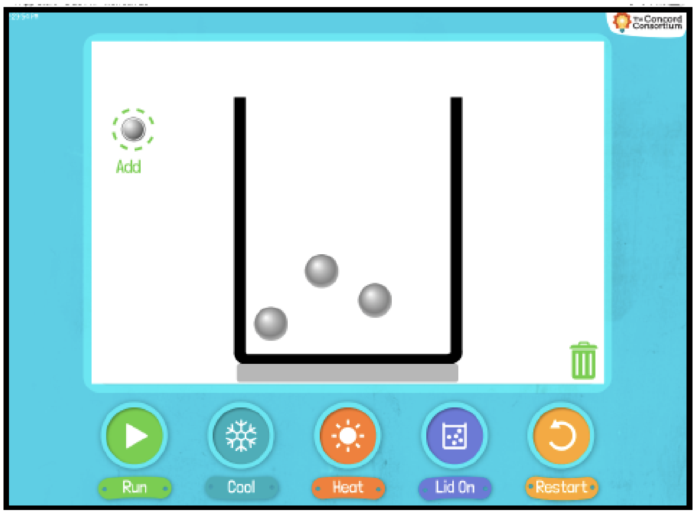
Navigating the App

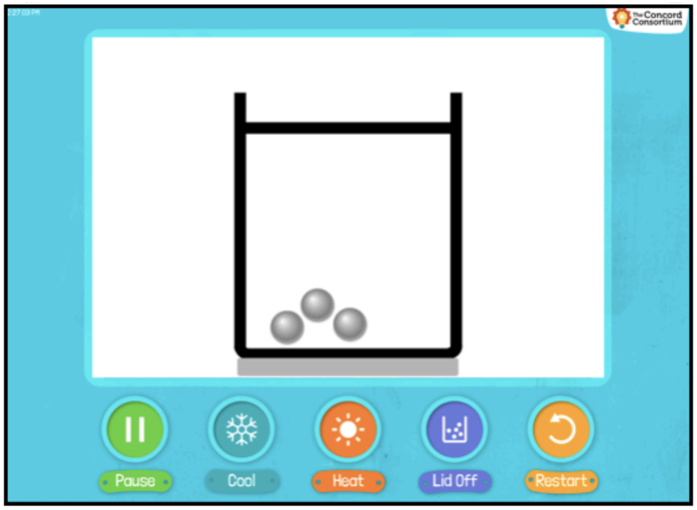
The first screen gives the children access to all the features of the Particle Modeler. One or more particles can be added to the inside (or outside) of the open container by touching and dragging the particle icon in the upper left. Touching the play simulation button at the bottom causes the particles to move and bounce at the default temperature. Increase the motion (temperature) by touching the sun icon. To decrease the motion (temperature), touch the snowflake icon. The particles behave according to the laws of physics. They become a solid if the temperature is sufficiently lowered or become a gas if sufficiently raised. Cover the container with a lid if desired, such as when the particles are about to fly out of the container as a gas.



Let children explore by adding two or three particles and then heating or cooling them.

How it Works

If the icons are not immediately clear, show the child how to add two particles and the start the animation. Encourage the child to watch what happens when she taps the sun icon. Note: tap the sun icon several times so that you can then show the child how to slow down the action by tapping the snowflake icon. Explain that the dots simulate what happens when ice melts, when a water puddle dries up, or when the water vapor turns to raindrops. Bridging the rather abstract nature of the Particle Modeler to the real events of everyday life will motivate the child to explore the Particle Modeler. At first, children may want to maximize the frenzy of many dots flying around bumping and falling. The goal is to treat the Particle Modeler as a model of microscopic events that we cannot see, but can infer events that are happening.



You can add a lid to the container to keep the particles from flying out.

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Talking About Discoveries

Support children's play in a manner that raises their curiosity about what might happen next as opposed to a random approach of just clicking and seeing. Use the following questions and comments during free play with the Particle Modeler. More structured suggestions are included in the next section on supplemental activities.

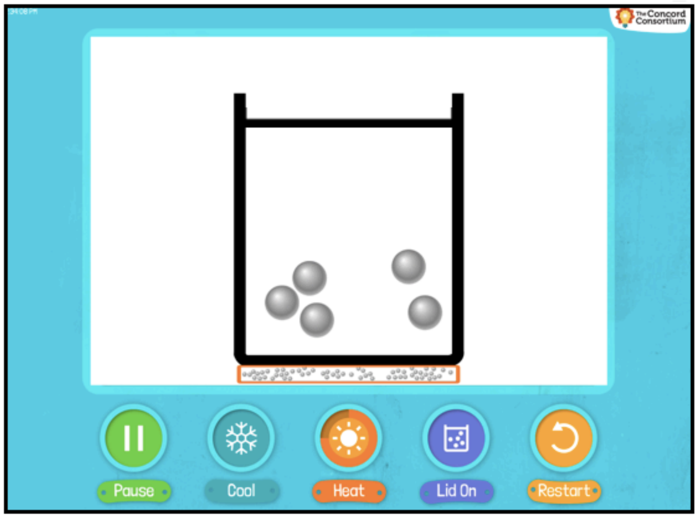
- The container in the Particle Modeler can't increase in size even if we add up to 20 particles inside the container. Some containers like a balloon can expand. How would 20 particles inside a balloon make it expand? [If you made the particles move faster and faster they would bounce more frequently against the inside of the balloon and push it out.]

- What if you wanted to move the particles with your hand without them coming apart. Can you show me what that would look like here using the Particle Modeler? [Children could make a group of particles that were cold (slow).]

- I noticed that time you increased the temperature but the liquid did not turn to a gas. Why not? [Listen for some mention that liquid can have faster particles than before but not so fast that they break their attraction to each other.]

- Did you notice that when you increased the temperature high enough that the solid particles start to change their arrangements and behavior like a liquid? What did you see? [Listen for some comment on how the particles separated a bit, but hopefully the children will also notice that the particles still stayed close to each other as they moved around.]

- Why do you think that liquid particles flow around each but do not fly all around inside the container? [Children may say that the liquid is not yet a gas. Listen for comments about the heat not being high enough or that the particles are still attracted to each other.]



Heat or cool the particles in a closed container and see if the children figure out how this action will increase or decrease the speed of the particles inside.

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Supplemental Activity: Relating the Macroscopic to the Microscopic

What to Do

There are a number of ways you can improve the chances that children treat the Particle Modeler as a simulation of microscopic events.

1) For example, if you put a balloon - not quite filled with air - near a light bulb it should expand slightly. How would the children model what causes this using the Particle Modeler?

2) Have children to touch a stone indoors and then again touch it after it has been out in the sun. The stone will feel hotter in the sun. Ask the children to use the Particle Modeler to simulate the stone particles.

3) Cover a glass loosely with plastic wrap so that all the air is trapped inside. Put a rubber band around the plastic wrap to keep it secure. Put the glass in warm water and notice how the plastic wrap loses any wrinkles and expands. Ask the children to use the Particle Model to show what is happening. Puncture a hole in the plastic wrap and do the warming again. Ask the children why the plastic wrap does not lose its wrinkles.

4) Give children a shallow bowl of liquid water. Explain that you want to carry the water without using the bowl. What can you do to the water so that you can carry it to a new place without using a container? Ask them to use the Particle Model to show what can be done (freeze it by lowering the temperature).

5) Position four or five particles at the bottom of the Particle Modeler container. Tap the Run Simulation button. While the Particle Modeler is still running, cool the particles down by tapping on the snowflake several times. Pause the simulation. Have the children place four particles above the container. Before you run the simulation, ask them to explain what will happen and why. Then tap the Run Simulation button. Summarize by describing how things melt and suggest that what they have just seen shows how warm air melts ice.

Purpose of the Activity

A knowledge of how particles behave at the microscopic level will help the child understand everyday experiences, such as how you can put your hand into liquid water but not into frozen water (the particles flow around your hand and do not fly off into space). The Particle Modeler also has the potential to help children understand air pressure inside a container. Gas particles that move faster hit the inside of the container more frequently. While this relation between frequency and pressure has no graphic consequence in the Particle Modeler, an adult could find ways to support a discussion about these relations such as using the transparent sheet on top of the iPad so students can draw their thoughts. In general, we want children to "read" the macroscopic world as a consequence of what particles do in the microscopic world.

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What to Notice

Children will try to stay at the macroscopic level at first. The cold stone feels warm because “the sun made it hot.” You can carry frozen water because it is hard. You can put your hand through water because it is liquid. It will take some encouragement to help children explain these same events in terms of particle behavior. The stone feels warm because the particles are moving faster and bump your hand a lot. You can carry frozen water because the particles are moving slower and do not come apart. You can put your hand in water because the particles are still attracted to each other but are not stuck together. Do not rush to tell children these facts and relations. It is important for children to come up with their own questions.

Children who ask questions often have a theory and their question narrows the set of answers that are relevant to the children’s own theory, a relevance that the children understand since they constructed the question. If facts come from you before the children have any logical or plausible reason to speculate about a possible relevance to a theory, then the facts just hang there in a vacant conceptual space.

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