Particle Patty

Particle Patty is a playful video animation that demonstrates the role of particle motion in solids, liquids, and gases. Particle interaction and the arrangements of particles within different states of matter are represented clearly for users of all ages.

Getting to Know the App

The Particle Patty video takes children on an imaginary tour inside the molecules of a single grain of sugar. The video emphasizes that a grain of sugar is not the same as a molecule. The teacher in the video, Mr. Watson, isolates a single grain of sugar and then zooms in to see the particles. Patty is one of the particles in the sugar grain; she is joined by her classmate Sam. Notice that there are dark particles in the background zooming around. Be sure that your students are aware of the background particles of air because they cause the grain of sugar to change from a solid to a liquid and then from a liquid to a gas. The air moves faster and bumps the sugar particles harder, knocking them out of the closely packed particles of the solid. Later, as the air particles are made to move even faster, they knock the liquid particles out of their flowing state to become gas that fly around with the air particles.

What it Teaches

A solid (grain of sugar) is made of particles that wiggle but do not change location. There is an unseen force that makes the particles move yet holds them together. The particles in a grain of sugar will remain together unless acted upon by another set of particles—the air particles. When the faster air particles collide with the particles in the solid, those particles separate and become a liquid. The air particles can increase in speed if heated with a flame. When the solid sugar particles are dislodged into a liquid, the particles lose their tight structure and collapse into a fluid at the bottom of the container. The liquid particles spread out more, move around each other, but do not fly off into the upper regions of the container.

If the air particles are made to go even faster by increasing the amount of heat, the air particles collide harder with the liquid particles and break the forces that have kept the liquid particles flowing close to each other. The particles become widely distributed, fly throughout the container, and have little attraction to each other as they did when they were a part of a solid or liquid. In the transformation from a solid to a liquid to a gas, the number of particles does not change. The particles only change their speed and their distribution.

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Particle Patty is designed to teach the following concepts:

- Matter is made of invisible particles that move.
- Solids particles wiggle close together and do not change their arrangement.
- The fast moving air particles bump the solid particles when heated by a flame.
- This bumping causes the solid particles to break apart.
- When the solid particles are broken apart, they flow close together as a liquid.
- A liquid is made of particles that stay close together but flow around each other.
- Mr. Watson's larger flame can make the air particles move even faster than before.
- Faster air particles can bump the liquid sugar even harder and make the sugar particles fly around like a gas. (Note that it is implied that increasing the speed increases the force of the impact.)

Navigating the App

Watch the video (4:45) from start to finish. The final question "How do you think we could get the gas particles to change back into a liquid?" is hypothetical, though you may decide to ask children to speculate on the answer. (Turn off Mr. Watson's flame to make the air slow down and bump the sugar gas more softly.)

How it Works

Children should watch the entire video once. Use the examples from the "Talking About Discoveries" section below to help children revisit key concepts. Rewind the video and pause it at key points to ask questions. There are natural places in the video to ask, "What do you think will happen?" or "What just happened?" More specific questions might include, "Why did the solid particles break apart?" Children may process such questions better after they have seen the entire animation from start to finish.

Talking About Discoveries

After working with Particle Patty for a while you may want to assess what the children have learned. Start with a general set of questions. Consider the following questions to pose to children:

1 What is the difference between a grain of sugar and a particle of sugar? [A grain is a small piece of sugar visible at the macroscopic level while a particle is an invisible element at the microscopic level of which the grain is composed.]

2 What causes the particles of sugar to change from being bound together to flowing around like a liquid? [The fast particles of air hit the particles of sugar in the solid state and break it apart.]

3 Can you think of any reason why the particles in a liquid stay close to each other? [The particles in a liquid move around each other, but there is an attraction among them that keeps them grouped together.]

4 Tell me about the air particles. How were they important in this story about the particles of sugar? [The speed of the air particles determined what happened to the sugar when the air particles bumped the sugar particles.]

5 How could we make a gas become a liquid? [You would have to cool the gas. You need slow particles bumping the gas particles so the gas particles would also slow down.]

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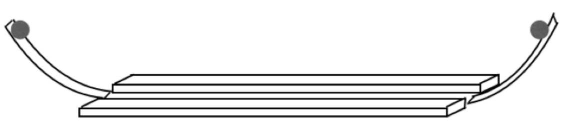
Supplemental Activity: Two Marbles Colliding

What to Do

This activity focuses on the idea that the result of a collision is based on the relative speeds of the two colliding objects. This idea requires some high-level thinking and children will benefit from seeing these events in the macroscopic world of rolling balls. Create a long track for large marbles (or steel ball bearings if available). Make the track about four feet long on a flat horizontal surface. You can use any number of ways to get the marbles to track in a narrow channel, such as gluing two strips of wood (e.g., cabinet edging or molding or some foam pipe insulation) in parallel onto a longer board. The foam insulation that has a groove can be bent, or just place books on a table so that a parallel channel is made between their spines. Make two additional tracks from cardboard that can be tilted for the marbles to roll down toward each other. Be sure that the end that touches the table is curved so the marbles will roll smoothly from the side ramp to the horizontal surface of the table.

This set-up can be used to ask the children to predict how far the marbles will roll after they collide. Ideally your track will be long enough so that when the two marbles of the same mass are released on opposite ends at the same time at a sharp incline they will collide and then eventually roll to a stop after they collide. If you release them at the same time at a shallow angle, the marbles should not roll as far backward after they collide.



Before you release the marbles, explain that a sharp incline will make the marbles roll fast and a shallow incline will make the marbles roll slow. Begin with the same shallow incline on both ends of the long track. The marbles will collide and bounce back rolling to a stop (at about the same distance from the point of contact). Mark the place where the marbles stopped. Now increase the angle so the marbles roll faster. Before you release the marbles ask children to predict where the marbles will roll to a stop. Encourage them to explain their predictions. Be alert to words like "hit harder" or "roll faster." Try to extend the discussion if they do not make a prediction about distances, such as "They will bounce" or "They will roll in opposite directions."

Vary the pitch of the inclines. It might be possible to introduce what happens when a fast marble hits a slow marble. To exaggerate this difference in speed, place one marble in the center of the track and then roll the other marble down a steep incline. Also, place two marbles in the center of the track and ask the children what will happen when a fast marble hits the two marbles that have been placed touching each other.

Purpose of the Activity

Children will need some help realizing that the result of an impact is directly related to the speed of the colliding objects at the time of the collision. Children may know that they can make a rubber ball bounce higher by throwing it down harder, but this knowledge may not be encoded as "the faster, the higher the ball goes." Experiments with rolling marbles into each other will help the children reflect on the event as an interaction between two variables, speed and distance traveled. Do your best to relate the marbles in the track to the way the air particles in Particle Patty bump into the sugar particles: the faster the air particles, the more distance they travel when they break apart.

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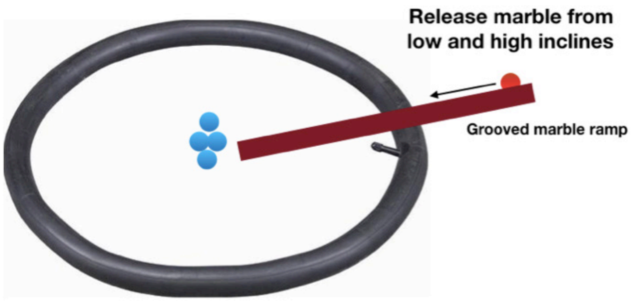
What to Notice

When you ask children to predict or explain, they may talk about the bumping, such as "they will crash." Help children to relate a cause to an effect, such as saying, "They will crash and bounce away from each other." Most importantly, notice any attempts to explain why different experiments produce different results. Children might say, "They hit harder that time" or "They were rolling faster than last time." Such comments indicate that the children are ready to explain the final resting position of the marbles in terms of the speed of the marbles when they collide: "They bounce back farther if they are going really fast when they hit." Occasionally children think that the two marbles change places in the track. The one on the right continues moving to the left and vice versa, as if the two marbles "pass through" each other rather than bounce and move in an opposite direction. If marbles are different colors, students may not think this way.

You may also try using the incline to roll a single marble into a cluster of marbles. Watch how the marbles disperse more when hit by a fast marble than by a slow marble. However, when hit by a slow marble, they will not flow around each other as tiny particles in a liquid might. Nevertheless, the marble demonstration might cause children to wonder why the sugar particles continue to flow near each other in Particle Patty when they become a liquid. Real marbles do not do that, so the children might invent some invisible force that keeps the liquid particles close as they flow around each other. Point out the differences (as well as the similarities) between the macroscopic world of colliding marbles and the microscopic world of colliding particles.



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Hypothetical Conversation

The conversation below represents an idealized whole-class activity between the teacher/parent(T) and children (C, which represents various children), and might be done after children have tried to retell the story of Particle Patty. Notice how the teacher continually moves from what happened to why it happened. The conversation, of course, idealizes how well the children understand the teacher's questions. Nevertheless, a real conversation will share some overlap with this idealized conversation, which can be a useful guide for how to respond to children's comments and answers.

T: Tell how the story of Particle Patty begins.

C: With a grain of sugar.

T: What happens next?

C: They shrink.

T: That's right. The camera zoomed in, so you could see the grain of sugar like through a microscope. What did you see?

C: A bunch of particles.

T: What do you mean by "a bunch"?

C: All piled together.

T: You mean the grains of sugar were piled together or something else?

C: The particles.

T: I see. The particles make up the single grain of sugar. Very good. So, what did Mr. Watson do next?

C: He turned on a flame.

T: Why did he do that?

C: To melt the sugar.

T: Yes, the sugar did change, didn't it? What happened to make it change?

C: The flame.

T: I don't understand. How can a flame change a grain of sugar?

C: It melted the sugar.

T: Yes, but the story told you what caused the sugar to melt. How?

C. I think the air melted the sugar.

T: Not the flame?

C: Both.

T: What did the air do to the sugar to make it change?

C: Oh, I know. The air bumped into the sugar.

T: Now we are getting somewhere. The air bumped the sugar particles and made them change. What sort of change was it?

C: The sugar became a liquid.

T: What is a liquid?

C: You know, a liquid, like water.

T: So the air bumped the sugar and changed it to water.

C: No, not water.

T: Okay, not water, but a liquid? I need to know what liquids are. What can you tell me about the particles in a liquid?

C: They are not together like before.

T: Oh, so compared to a solid, the particles in the liquid are not together?

C: Well, they are a little bit.

T: Yes, they sort of stay close to each other. Can you say anything else about what the particles do when they are part of a liquid?

C: They stay close to each other.

T: That's right. Anything else?

C: (No answer about increase in speed of the sugar particles or flowing around each other.)

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Hypothetical Conversation (continued)

T: So the air bumped the sugar particles and broke them apart so they flowed at the bottom of the dish like a liquid. They moved around each other, but stayed close together. Remember that Sam wanted to be free and not stay close to all the other particles. What happened next?

C: He flew all around.

T: So he just jumped out of the group like a frog?

C: No.

T: Tell me how he was able to get away from the particles in the liquid.

C: He became a gas.

T: Well, that's true. That is what we call the change from a liquid, but I need you to tell me what caused the change.

C: Mr. Watson did.

T: By doing what?

C: By turning on the flame.

T: I thought he already did that to make the solid become a liquid.

C: He did it again.

T: Why didn't Sam fly away from the solid when Mr. Watson first turned on the flame?

C: He wasn't ready.

T: Now, remember, these are particles, not really little people. What had to happen for the liquid particle to become a gas particle?

C: The flame.

T: What did the flame do?

C: It heated things up.

T: What heated it up?

C: The air.

T: The flame heated up the air. Tell me again what it means to heat things up.

C: The air gets hotter.

T: And what does the hotter air do to the particles in the liquid?

C: The air bumps the particles.

T: The hotter air bumps the particles in the sugar. What happens after the bumps?

C: The particles become a gas.

T: So the hotter air bumps the liquid particles and makes them become a gas. Tell me how you know it is a gas.

C: Because Sam is flying around. They are all flying around.

T: I see. The hot air bumps the liquid particles and those particles are bumped out of the close group and start to fly around all over the room. But let's think about it some more. The hot air bumped the solid particles, but the solid did not become a gas. It became a liquid. Why didn't the solid become a gas?

C: Because they were close together.

T: That is what I want to understand. Why did the solid particles stay close together after they were bumped by the hot air?

C: Maybe the air was not hot enough.

T: Now that is an interesting idea. Maybe the air was not hot enough to make the solid become a gas. What do you mean, "the air was not hot enough"?

C: It was not hot enough to make the solid change to a gas.

T: Why not?

C: Just because.

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Hypothetical Conversation (continued)

T: What do we know about hot and hotter? What happens to the particles when something gets hotter?

C: It goes faster.

T: What goes faster?

C: The particles.

T: So you are saying that air particles were not fast enough to make the solid become a gas?

C: Yes.

T: How does that work? Why do faster particles break up the sugar particles better than slower particles?

C: They hit harder.

T: Got it. So when Mr. Watson heated up the air the second time, he made them hotter than before and that made them go faster than before. So when they hit the particles in the liquid really hard, it becomes a gas. He probably could have made the solid become a gas, too, if he had heated up the air to go super fast and bump the solid particles super hard.

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