Thermoscope with probes

With the Thermoscope you can "see" temperature as the speed of particles. This educational app provides a simplified visualization of particle configuration and movement for temperature differences between materials.

Getting to Know the App

To connect the iPad to the Bluetooth fast-acting temperature probes, click the "Connect" button in the upper left on the first screen of the iPad. Then press and hold the black button on the top of the container with the two probes. Click Thermoscope-paired with the icon that matches the container of probes in the pop-up menu and the blue "Pair" button. A green checkmark and the word "Connected" will appear in the upper left of the screen. The Table of Contents iPad screen includes symbols of various solids and liquids as well as one gas ("Air").

Once the child chooses a material, a screen will appear with a picture of two magnifying glasses with dotted lines converging to a small portion of the chosen materials, representing magnified views of those materials. You should have these physical materials (e.g., wood and stone) available for children to touch with probes A and B. Help the children understand that the ring of moving particles is not a container, but rather is a "peephole" into a small section of the material. We designed this screen to reduce children's tendency to believe that seeing fewer particles inside the ring at higher temperatures means some particles have escaped the material. The other particles are just out of view of the peephole.

What it Teaches

The Thermoscope reframes temperature as the speed of particles, rather than the more common assumption that temperature increases by adding more "hot stuff." When the child places one of the probes on or in something that is warmer than the ambient air, the child will see an increase in the speed of the particle display for that probe. The motion will slow down if the material is colder than the ambient air. The Thermoscope allows the child to choose two different materials in the same state (e.g., wood and stone). The Thermoscope also allows the child to watch what happens to the particles when hot and cold water are mixed and what happens when coconut paste is heated and changes states from a from a solid to a liquid. This visualization tool gives the child freedom to explore the microscopic world of particle physics.

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Thermoscope with probes

Navigating the App

The The first screen gives the child choices for materials (e.g., water, coconut) or the option to experiment in specific ways. Touching the home (house) button at the top returns the screen to the Table of Contents top menu. Use the "hamburger" icon (three horizontal lines) in the upper right for the Options menu, which allows you to add "Hide/View" buttons, "Play/Pause" buttons as well as to change the Celsius degrees to Fahrenheit degrees on the main display.

Once the child selects the materials, two magnifying glasses appear, pointing at the chosen material(s) that are present in front of the child. For example, touch the oil and soap choice and the screen changes to two microscopic views of fluid particles moving at room temperature. If the child selects oil and it is warmer than the soap, placing the probes in each liquid will show the oil particles moving faster than the soap particles. If the child selects the coconut, then only one lens appears. If you insert probe A into the coconut paste and then warm the coconut paste under a lamp, the cluster of particles in the Thermoscope begin to separate from a lattice structure and flow as particles in a liquid state in correlation with the paste turning to oil. Note the movement ("ghosting") of the needles in the temperature gauge under the microscope(s).

Touch the home icon in the upper right to return to the Table of Contents and select the "Experiments" symbol. If you select "One View," the child can explore temperature variations with one of the seven materials. If you select the "Mixing View" the child can see what happens when hot water is mixed with cold water. Set out one glass of cold water and one glass of warm water. Place Probe A in the cold water and Probe B in the warm water. Click the x to dismiss the setup view. Notice the slow particles in the A microscope and the fast particles in the B microscope. Continue by clicking on the double magnifying glass icon at the bottom middle of the screen.

Watch the demo, then close the window by clicking the x, and quickly pour equal amounts of hot and cold water into an empty third glass with both probes inserted into this third glass. The particles in the mixed view will show a temperature half way between the hot and cold temperatures of each separate glass. Although the temperature change occurs rather quickly, the fast B particles bump into and speed up the slower A particles and the slower A particles bump into and slow down the faster B particles. This gradual change to equilibrium can be seen somewhat better using the Thermonator app. (You can download the Thermonator from the Apple App Store.)

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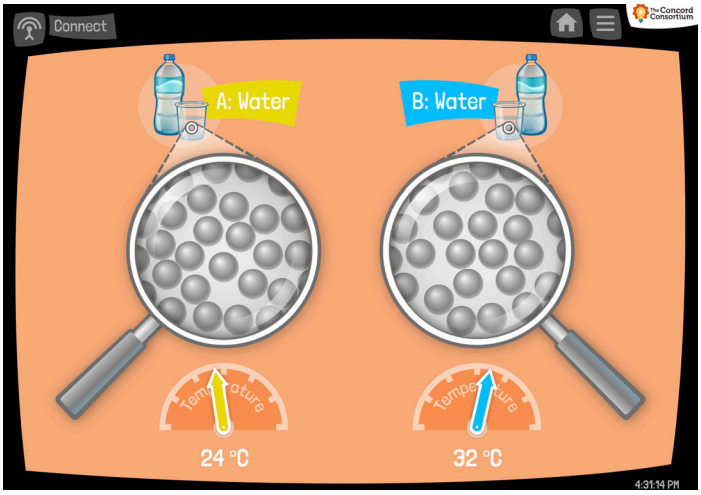
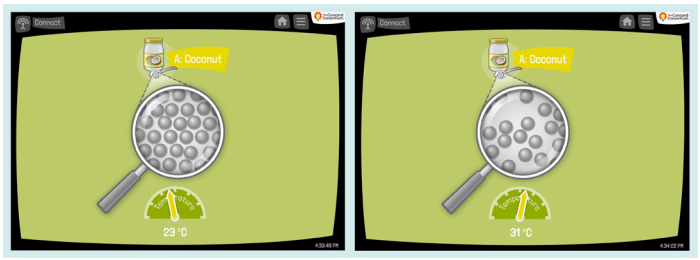
How it Works

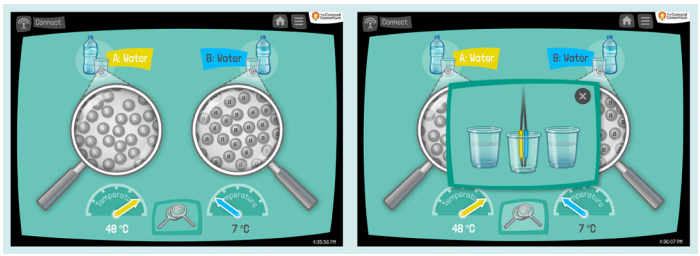
This introduction focuses on the Thermoscope with two fast-response temperature probes. In this case children choose the material (e.g., wood, air, etc.) and watch what happens to the particles inside the magnifying glass as the children touch Probes A and B to materials in different states and different temperatures. Children can use a single probe or both probes at the same time. (To order the Thermoscope kit for a small fee, please email help@concord.org.) On the iPad, the Thermoscope app can be run without the temperature probes.

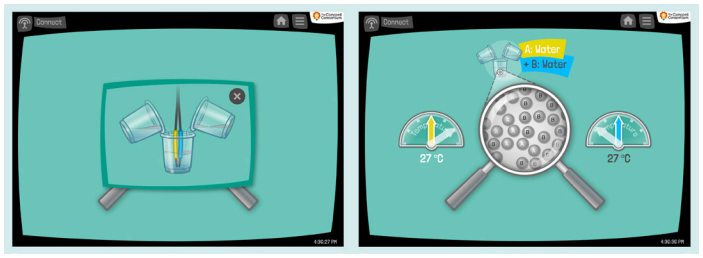


Thermoscope A shows the particle movement is slower in the first water glass (24° C) and Thermoscope B shows faster particle movement in the second water glass (32° C).



The change in the temperature of the coconut paste when it is placed in a warm water bath will trigger a phase change from solid to liquid in the model.





Mixing of two water samples can be done by inserting Probe A in the first glass and Probe B in the second glass once the Thermoscope is connected. Click the two magnifying glasses at the bottom of the screen and follow the two pop-up instructions to combine the samples.

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Thermoscope with probes

Talking About Discoveries

Support children's play in a manner that raises their curiosity. Use the following questions and comments during their free play with the Thermoscope. Additional structured suggestions are provided in the next section on Supplemental Activities. The following suggestions are limited to the choices of materials available on the Table of Contents for the Thermoscope app.

Focus questions or comments on these concepts:

- Sometimes particles change state as they change speed (coconut).
- Sometimes particles change speed without changing state (all except coconut).
- Some particles of different materials begin to move very fast at lower temperatures than other materials.
- Mixing fast and slow particles will result in a medium speed.
- Particles in different states vary in closeness and flow.

1. "Let's look at the particles in stone and wood. Now let's look at the particles in oil and soap. Can you tell me what you remember about the particles in the solid material that is different from the particles in the liquid material?" (Note if the children mention both the relative distance of the grouping and the speed of the particles.)

2. "I see that the particles in the oil start to move very fast after you warm it with the lamp. The lamp increases the speed of the air that surrounds the oil. Can you figure out how the warmed air makes the particles in the oil move faster?" (Note if the child talks about fast air particles bumping the oil particles.)

3. Let the child explore the "Mixing View" under the Experiments menu. Then ask questions such as "Can you think of any reason why the warm water cools down and the cold water warms up?" Help the child to notice the "ghosted" needles on the temperature gauge that represent the original hot and cold temperatures that have now changed to medium.

4. After the child has explored how temperature change affects the particles in coconut paste, stone, water, and air, remind the child that the coconut changed from solid to liquid, but none of the other materials did. "Can you make up a reason why the coconut solid became a liquid when heated but stone did not become a liquid when heated?" (Note if the child says she could not make the temperature high enough or if she thinks about it being harder to separate the particles in the stone.)

Thermoscope with probes

Supplemental Activity: The Pretend Thermoscope

What to Do

Roll a sheet of paper into a tube with a diameter of approximately one inch. Tape the paper roll so it does not unfurl. To help children play the game of "Pretend Thermoscope," ask them to look at the iPad display to see the dots. Then tell the children that they now have their own more powerful Thermoscope they can use to see particles moving inside anything they view through the tube. Ask the children to look through the paper Thermoscope at a cloud or at a hot sidewalk or the top of a tree. Ask them to describe what they would see if their pretend Thermoscope really worked to see the particles. Ask what the particles are doing. Find conditions where the temperature is changing, such as how their hands feel when taken out of gloves on a cold day. What are the particles of the hand doing over time? The particles in the glove?

Purpose of Activity

This activity moves children to make predictions rather than to confirm speculations with the probes. Children should venture further into their own understanding of particle physics. The pretend Thermoscope should help the child generalize her knowledge to a wider range of materials and conditions.

What to Notice

Notice what objects the children select to look at with their pretend Thermoscopes. Do they choose objects that are in different states of mater? Do they choose objects that might change states (e.g., water puddle on the hot pavement)? Do they choose objects that already look like particles (e.g., sand)? Notice if their explorations and speculations begin to represent a more systematic view of particle physics. Listen to their reasons for their choices for what they explore. Children may make fantastic comments. Their fantasy can contain the grain of normative physics ideas. Encourage all comments and follow their lead in exploring their ideas.

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