Thermoscope

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

On the Table of Contents screen you will see symbols of various solids and liquids, as well as a symbol for air as one gas. Once the child chooses a material a screen will appear showing a picture of a magnifying glass with dotted lines converging to a small portion of the chosen material, representing magnified views of those materials. Help the children understand that the ring of moving particles is not a container, but rather 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 increases the temperature by moving the arrow on the temperature gauge the child will learn that heating a material increases the speed of its particles. The Thermoscope also allows the child to select two different materials in the same state (e.g., wood and stone). In addition, the Thermoscope app allows the child to watch what happens when hot and cold water are mixed and what happens when coconut paste is heated and changes states 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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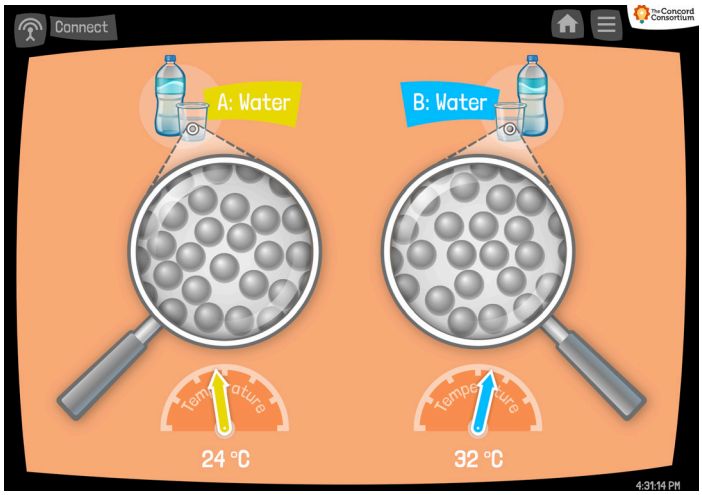
Navigating the App

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 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 selected material(s) to show what the particles are doing. For example, touch "Wood & Stone" and the screen changes to two microscopic views of what the molecules are doing in each material at 20 degrees Celsius. Move the needles on the temperature gauges to increase or decrease the temperature and watch the particles change speed. If the child chooses coconut, only one magnifying glass appears. As the temperature increases, notice that the cluster of particles begins to separate from a lattice structure and begins flowing as particles in a liquid state.

Touch the home icon in the upper right to return to the Table of Contents screen and select the "Experiments" symbol. If you select "One View" the child can explore temperature variations with one of the seven materials. If you then select the "Mixing View" the child can see what happens when hot water is mixed with cold water. Initially both glasses of water are preset at 20 degrees Celsius. Make one glass colder and one glass warmer.

Continue the experiment by watching, then closing, the demos and clicking on the magnifying glass icons at the bottom middle of the screen. The particles in the mixed view will show a temperature half way between the cold and warm temperatures of each separate glass. The temperature change occurs rather quickly and the child may not see the gradual equilibration due to fast particles and slow particles colliding. This gradual change to equilibrium can be seen somewhat better using the Thermonator app. (You can download the Thermonator from the Apple App Store.)



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).

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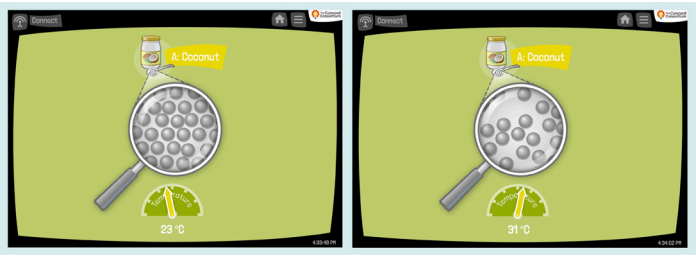
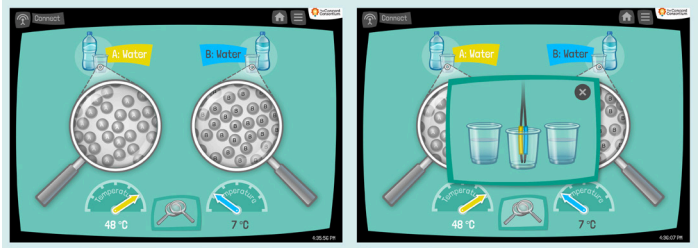
How it Works

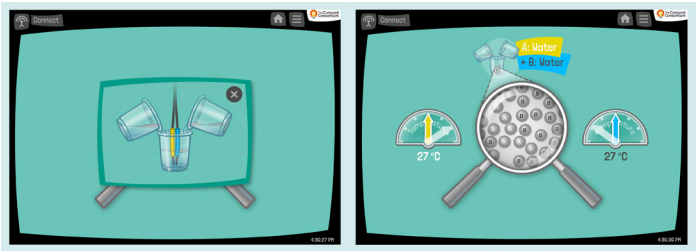
This introduction focuses on the Thermoscope without external temperature probes. In this case children choose the material (e.g., wood, air, etc.) and watch what happens to the particles inside the magnifying glass as the children increase or decrease the temperature by touching and moving the needle in the temperature gauges at the bottom of the respective screens.

The Thermoscope app can also be run with two-fast response temperature probes that can be connected by Bluetooth. (To order the Thermoscope kit, please email help@concord.org.) You can ignore the "Connect" button in the upper left corner if you do not have the Thermoscope kit with the two temperature probes and click and slide on the arrow inside the temperature gauges to move the temperature higher or lower.



When the temperature of the coconut paste is increased, it will trigger a phase change from solid to liquid in the model.





Mixing of two water samples can be done by sliding the arrows inside the temperature gauges to show different temperatures of each sample (A and B). 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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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.

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 move the needle to the right to make the oil hotter. By moving the needle you are adding warm air that surrounds the oil, like warm air from a flame. Can you figure out how the warm 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 cold and warm 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.)

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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 the children to make predictions rather than to confirm speculations. In this activity 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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