2.0 Heat affects matter in different ways

2.1 States of Matter and The Particle Model of Matter

Matter is made up of tiny particles and exists in three states: solid, liquid and gas.
The Particle Model of Matter is a scientific description of the tiny particles that make up all things.
The key elements in this model are:

- **All matter is made of tiny particles too small to be seen**
- **The particles are always moving**
- **The particles have spaces between them**
- **Adding heat to matter makes the particles move faster**

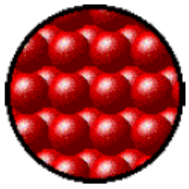
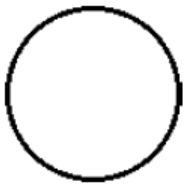
Changes of State: Water

Substances such as water (or wax) can undergo observable changes through all three states of matter - solid liquid and gas.

- Ice is the **solid state** of water at 0°C
- The **melting point** of water is 0°C
- The **boiling point** of water is 100°C
- **Condensation** occurs when water changes from a gas to a liquid

Any pure substance can exist in all three states of matter.

Heat and the Particle Model

Solid	Liquid	Gas
		
Particles are closely packed together	Particles can slip past each other	Particles have lots of space between them

The Effect of Heat on Particles

When heat is added to a substance, the particles move faster. When heat is lost from a substance the particles move slower.

- The motion of the particles increases when the temperature increases.
- The motion of the particles decreases when the temperature decreases.
- Heat energy transfers from high temperature matter to low temperature matter. Heat can affect matter by causing it to change state.

How The Particle Model Explains Changes of State

During a phase change, the average energy of the particles remains the same, but, the particles are rearranging themselves.

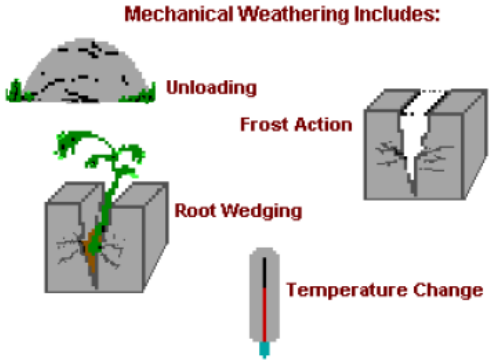
Solid	• The particles are tightly packed together. • Solids have a fixed shape.
Heating a Solid	• Particles become less organized as their energy increases, so the substance changes from a solid to a liquid to a gas. • The space between the particles increases, so its volume increases.
Melting a Solid	• Particles move very quickly and attractions between the particles break down, so the solid melts into a liquid state.
Liquid	• In a liquid, the particles are moving very quickly. • The particles have more kinetic energy • Liquids take the shape of their containers
Heating a Liquid	• At the surface, some of the particles are able to escape into the air, while others do not have enough energy to escape and remain in the liquid. • As the liquid expands, its volume increases • As high energy particles escape, the average energy of the remaining particles is less and so the liquid cools. The cool liquid then cools the surface on which it is resting. This is called evaporative cooling. It is common and useful in many situations: Joggers cooling down as their sweaty clothes dry out; Water cools down a roof on hot summer day; A wet cloth is placed on your forehead when you have a fever.
Boiling a Liquid	• The attractions between the particles are very weak • More and more high energy particles escape, and the liquid changes into a gas
Gas	• Particles move very quickly with a lot of kinetic energy • Particles fill up the space of the container they are in. • Large spaces between the particles.
Gas to a Liquid to a Solid	• As the energy of the particles becomes less, the particles rearrange themselves more orderly, so a gas changes to a liquid and then to a solid, when even more energy is lost – the particles are slowing down.

The total energy of the particles changes - by increasing or decreasing, because the particles are not increasing or decreasing their speed, just their arrangement. The average energy doesn't change. The energy change is hidden from a thermometer and is called **'hidden heat'** or **'latent heat'**.

2.3 Heat Affects the Volume of Solids, Liquids, and Gases

Observing The Effect of Heat

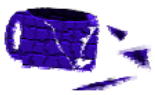
Cracks in rock, due to ice



Fitting a nut to a bolt

Hot water opens a jar lid

Boiling water cracks the cold mug



Thermal expansion is the process of expansion of a substance caused by an increase in thermal energy.

Expansion and Contraction in Solids	Solids can become longer or shorter depending on the temperature (average energy of the particles).
Expansion and Contraction in Liquids	When the particles in a liquid are heated, their average energy increases and they need more room, so they **expand**. When the particles in a liquid are cooled, the volume decreases, or **contracts**, because the particles need less room. This is demonstrated by the liquid used in a thermometer. As the liquid expands and contracts, it moves up and down the inside tubing (the *bore*) of the thermometer.
Expansion and Contraction in Gases	When the particles in a gas are heated, their average energy increases and they need more room, so they **expand**. When the particles in a gas are cooled, the volume decreases, or **contracts**, because the particles need less room. Under extremely high temperature conditions (like the temperatures inside the Sun, particles can be split into what makes them up (electrons and ions). This creates a fourth state of matter called **plasma**.

Heat Affects the Volume of Solids, Liquids and Gases

As the average energy of particles increases, the space between the particles increases. They expand (increase their volume) as the temperature increases. As the average energy of particles decreases, the space between the particles decreases. They contract (decrease their volume) as the temperature decreases.

	Solids	Liquids	Gases
Shape and Size	**Keep their shape and size**	**Take the shape of the container**	**No definite shape or size**
Compressibility (volume)	**Cannot be compressed (fixed volume)**	**Almost incompressible (fixed volume)**	**Can be compressed (volume changes)**