Heat is different from temperature.

Heat and temperature are very closely related. However, they are not the same. Temperature is a measurement of the average kinetic energy of particles in an object. **Heat** is a flow of energy from an object at a higher temperature to an object at a lower temperature.

If you add energy as heat to a pot of water, the water's temperature starts to increase. The added energy increases the average kinetic energy of the water molecules. Once the water starts to boil, however, adding energy no longer changes the temperature of the water. Instead, the heat goes into changing the physical state of the water from liquid to gas rather than increasing the kinetic energy of the water molecules. This fact is one demonstration that heat and temperature are not the same thing.

HEAT AND THERMAL ENERGY

Suppose you place an ice cube in a bowl on a table. At first, the bowl and the ice cube have different temperatures. However, the ice cube melts, and the water that comes from the ice will eventually have the same temperature as the bowl. This temperature will be lower than the original temperature of the bowl but higher than the original temperature of the ice cube. The water and the bowl end up at the same temperature because the particles in the ice cube and the particles in the bowl continually bump into each other and energy is transferred from the bowl to the ice.

Heat is always the transfer of energy from an object at a higher temperature to an object at a lower temperature. So energy flows from the particles in the warmer bowl to the particles in the cold ice and, later, the cooler water. If energy flowed in the opposite direction—from cooler to warmer—the ice would get colder and the bowl would get hotter, and you know that never happens.

When energy flows from a warmer object to a cooler object, the thermal energy of both of the objects changes. **Thermal energy** is the total random kinetic energy of particles in an object. Note that temperature and thermal energy are different from each other. Temperature is an average and thermal energy is a total. A glass of water can have the same temperature as Lake Superior, but the lake has far more thermal energy because the lake contains many more water molecules.

MEASURING HEAT

The most common units of heat measurement are the calorie and the joule (jool). One **calorie** is the amount of energy needed to raise the temperature of 1 gram of water by 1°C. The **joule** (J) is the standard scientific unit in which energy is measured. One calorie is equal to 4.18 joules.

You probably think of calories in terms of food. However, in nutrition, one Calorie—written with a capital C—is actually one kilocalorie, or 1000 calories. This means that one Calorie in food contains enough energy to raise the temperature of 1 kilogram of water by 1°C. So, each Calorie in food contains 1000 calories of energy.

How do we know how many Calories are in a food, such as a piece of chocolate cake? The cake is burned inside an instrument called a calorimeter. The amount of

energy released from the cake through heat is the number of Calories transferred from the cake to the calorimeter. The energy transferred to the calorimeter is equal to the amount of energy originally in the cake. A thermometer inside the calorimeter measures the increase in temperature from the burning cake, which is used to calculate how much energy is released.

1. How is thermal energy different from temperature?

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2. How is heat measured?

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