wanting all that energy to get stored as fat, he figures all he needs to do is exercise them off. By doing this, he knows that his body transfers energy from fat into the energy his body needs when he exercises. His favorite thing to do is run, so he decides that he will just go for a run and run long enough to cause his body to "burn off"—or use—1,000Cal. Now, he just needs to figure out how long he needs to run at his usual speed to use up 1,000Cal. His mass is 80kg and he usually runs at 9.6km/h (6 miles per hour). Running at that speed, an 80kg person will use about 130Cal for every kilometer he runs. Therefore, he calculates that he needs to run 1,000Cal ÷ 130 Cal/km = 7.7km, to burn off 1,000Cal of cookies. If he runs at 9.6 km/h, it will take him 7.7km ÷ 9.6km/h = 0.80 hours, or 48 minutes, to run 7.7km.

Now, as a final note for the sake of completeness, humans are not 100% efficient at converting the energy they consume into useable energy for the body, which means that not all the cookie-calories he ate will need to be burned off; therefore, he doesn't need to run quite as far as he thinks to work off those calories. But he doesn't know that, so he runs for the 48 minutes!

4.7 SPECIFIC HEAT

When heat is transferred from one object to another, we know that energy is transferred from the warmer object to the cooler object so that the warmer object gets a little cooler and the cooler object gets a little warmer. Once heated, you might have noticed that some objects stay hot for longer than other objects (or noticed the opposite, that some objects cool a lot faster than others). For example, the dough part of chocolate chip cookies usually cools very quickly, but the chocolate chips stay hot for a lot longer and are the reason you need to be careful eating them when they just come out of the oven. Or, if you pour hot liquid into a glass, the glass gets hot very quickly, but the glass cools very quickly as you pour out the hot liquid, as opposed to the liquid itself that takes forever to cool down. How much will the temperature of the cooler object increase when it is heated? Is there a way to know that, or figure it out? Why do some materials hold onto heat much longer than others?

The answer to these questions is a physical property of matter called **specific heat** (or specific heat capacity). Specific heat is the quantity of heat required to raise the temperature of 1 gram of a material (any material) by 1°C. Specific heat value varies by material, and there is a list of some values for various materials in **Figure 4.7.1**.

Figure 4.7.1

Specific Heat Values of Selected Substances

Specific heat values are usually expressed in one of two values—cal/g°C or J/g°C. To get from cal/g°C to J/g°C, multiply the calorie-based value by 4.186. I bolded the value for water because water has the highest specific heat of any naturally occurring substance. Water's high specific heat is a very important property that causes it to be perfect for sustaining life. The higher the specific heat, the more heat a substance must absorb to raise its temperature by 1°C, and the longer it takes to lose its heat. It takes a lot of heat to warm water up, just as it takes a long time for water to cool down because water's specific heat value is so high. Being slow to warm and cool causes the oceans to provide a heat buffer for the entire planet so it doesn't have rapid fluctuations in temperature. This is an important life-giving function of water.

Substance	Specific Heat in cal/g°C	Specific Heat in J/g°C
Aluminum	0.215	0.900
Ethyl alcohol	0.58	2.4
Copper	0.093	0.39
Glass	0.20	0.84
Gold	0.031	0.126
Marble	0.21	0.860
Mercury	0.033	0.14
Silver	0.0558	0.233
Steel	0.11	0.45
Water	**1.00**	**4.186**
Wood	0.40	1.7