The science of water

Description of water

Pure water is a colourless (transparent), odourless, tasteless substance that freezes at 0 °C, boils at 100 °C, and is liquid in between those temperatures. Completely pure water rarely occurs in nature because water is a good solvent—it readily dissolves and transports ions and compounds in solution. Water can also carry undissolved fine particles in suspension. Rivers often look green or brown because of the sediment (sand or mud) that they carry in suspension.

The water molecule is made up of two atoms of hydrogen and one atom of oxygen. This combination is written in the shorthand of chemistry as H_2O. Each of these elements, hydrogen and oxygen, is an invisible gas; when they combine chemically, they form water. The vapour rising from heated water (steam) is invisible. A mist becomes visible when the steam comes in contact with cooler air around it, forming tiny droplets of water suspended in the air.

The water cycle

Water exists in three states on earth. It is solid in the regions of the polar ice caps and in glaciers; liquid in the oceans, lakes, rivers and underground artesian basins; and a gas in the atmosphere. (Refer to Section 3, page 6, for more detail.)

Water is recycled between the earth and the atmosphere in a process called the water cycle. Understanding the water cycle requires an understanding of evaporation, condensation and melting. These changes of state are not readily understood by younger students who often believe that when water evaporates (and disappears), it ceases to exist. Even older students may struggle with the idea that water molecules are particles that are constantly moving—even in ice, which is solid.

Similarly, when students see water condensing on the side of a cold glass, they may believe that the condensed water came through the glass, or that the 'coldness' is coming through the glass. Some students also apply these misconceptions to their understanding of clouds.

The key concepts for understanding the water cycle are:

- air contains water vapour, which is invisible
- when water evaporates, it changes into an invisible form
- the amount of water vapour in the air (the humidity) can vary
- water evaporates from the surface of bodies of water like oceans, lakes and rivers, and from plants' leaves to form water vapour in the air
- when water vapour condenses it forms tiny water droplets
- when enough of these water droplets join together, they fall as rain under the effects of gravity
- evaporation separates water from solids that are dissolved in it; this is why rain is not salty.

By the end of primary school, students should understand that even though water exists in three different states, it is still the same substance. When water changes state (i.e. from solid to liquid to gas), it undergoes a physical change; a chemical change would be necessary in order for it to become a new substance. Water exists as a liquid at temperatures between 0 °C and 100 °C at atmospheric pressure.

The states of water

Solid—At temperatures below 0 °C, water forms a solid called ice. Ice is one of the very few solids that is less dense than its liquid form; most solids are more dense than their parent liquid and they sink. Because ice floats, it creates a 'blanket' over the water, insulating it from freezing further. If ice sank as it formed, the seas and oceans, the lakes, rivers, ponds and dams in colder latitudes would potentially continue to freeze until all the water was ice, and all the creatures in the water were frozen to death.

Ice absorbs heat energy when it melts, and releases that energy when it freezes. The enormous quantities of ice in the earth's polar environments (the Arctic and the Antarctic) act as a 'buffer' of thermal energy, preventing extreme changes in surface temperatures and so moderating the climate. Without the thermal buffering effect of polar ice, the earth would be much less windy (wind is important for distributing energy over the earth's surface), and it would be much colder. So the weather patterns that make our world a place that we can live in are largely shaped by the melting and freezing of polar ice.

Liquid—Most of the liquid water on earth exists as a salt solution in the oceans, with smaller quantities of fresh water in lakes, rivers and clouds. The earth is in a unique position within the solar system; it is just far enough away from the sun to allow liquid water to exist in significant quantities. If it were closer to the sun, all water would be gaseous; if it were further away, all water would be ice.

Gas—Water vapour is technically a gas. Clouds form when water vapour rises into the atmosphere, where the air pressure and temperature are lower. Here, the water vapour is cooled and droplets of water form. It is these droplets of water that form as mist, fog and clouds.

The amount of gaseous water vapour in the air is measured as humidity. Air humidity is another very important modifier of climate. The increased humidity of air in the tropics keeps temperatures in the 30 °C range, unlike the drier air (lower humidity) in desert regions where temperatures of 40 °C to 60 °C are reached.

Characteristics of water

Liquid water has no definite shape. Typically, water occupies a set volume and flows to fill the shape of its container. Unlike gases, liquids such as water cannot be compressed under everyday conditions.

Water molecules tend to stick together because of the forces of attraction between them (known as the force of cohesion). The cohesive force between water molecules explains why water can flow. Water molecules can also stick to other molecules on some surfaces they come in contact with. This 'wetting' is called adhesion.

Water and the human body

The human body consists of approximately 60% water.

Table 5: Water held in parts of the human body

Water storage areas of the body	% water held in those tissues
muscles	75
brain	75
blood	82
bones	25

A 2% drop in body water may result in fuzzy short-term memory and difficulty in concentrating. These conditions might indicate the early stages of dehydration.

Depending on activity levels and dietary intake, children from 1 to 13 years require 1.0 to 1.6 L of water every day to prevent dehydration and sickness.