8

"If there is magic on this planet, it is contained in water." – Loren Eiseley

A Journey through States of Water

The Big Question

Imagine water. Simple, right? But can you picture it as a solid, hard enough to walk on, or as an invisible gas floating in the air? Water is a true marvel, constantly changing its form all around us! From the refreshing liquid we drink to the fluffy clouds above and the icy wonders of the poles, how does this incredible substance transform? This chapter will explore the fascinating science behind water's different states and its constant journey through nature.

Meet EeeBee.AI

Hello, curious water explorers! I'm EeeBee, your AI buddy. Let's delve into water's states—solid, liquid, gas—and how energy drives its amazing changes!

Still curious? Talk to me by scanning the QR code.

Learning Outcomes

By the end of this chapter, students will be able to:

- Understand the three primary states of water and their characteristics.
- Identify the factors that influence the rate of evaporation in different scenarios.
- Comprehend how evaporation plays a role in cooling mechanisms.
- Appreciate the value of water conservation and discover practical ways to save water in daily life

From Last Year's Notebook

- Particle Arrangement and States of Matter
- Matter, Solutions, and Their Properties
- Some Properties of Water

Science Around you

Water is essential for all life on Earth. Its ability to exist in solid, liquid, and gaseous states drives weather patterns, shapes landscapes, and plays a crucial role in biological processes. Understanding these transformations is key to comprehending our planet's climate, ecosystems, and even daily phenomena like rain or dew.

NCF Curricular Goals and Competencies

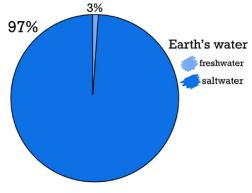
CG-1 (C 1.2): Explores the properties and behaviors of matter, focusing on its different states and transformations. **CG-6 (C 6.2):** Examines scientific phenomena, including the water cycle, while fostering scientific thinking and inquiry-based learning to develop critical understanding.

Mind Map

A Journey through States of Water

The Science of Water

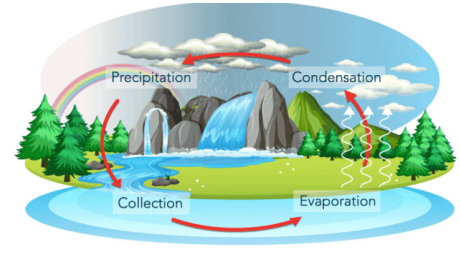
- **Water Distribution on Earth (image)**
  - ✓ Oceans (71% of Earth's surface)
  - ✓ Freshwater (Rivers, Lakes, Ice Caps)



- **States of Water**
  - ✓ Solid (Ice)
  - ✓ Forms at 0°C or below
  - ✓ Ice Caps, Snow, Glaciers
  - ✓ Liquid (Water)
  - ✓ Most common state on Earth
  - ✓ Found in oceans, rivers, lakes
  - ✓ Gas (Vapor)
  - ✓ Water vapor in the atmosphere
  - ✓ Invisible gas form

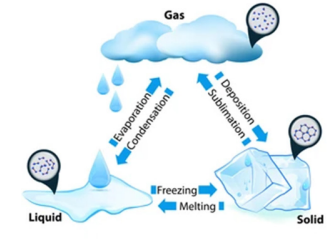
Evaporation and Its Role in Nature

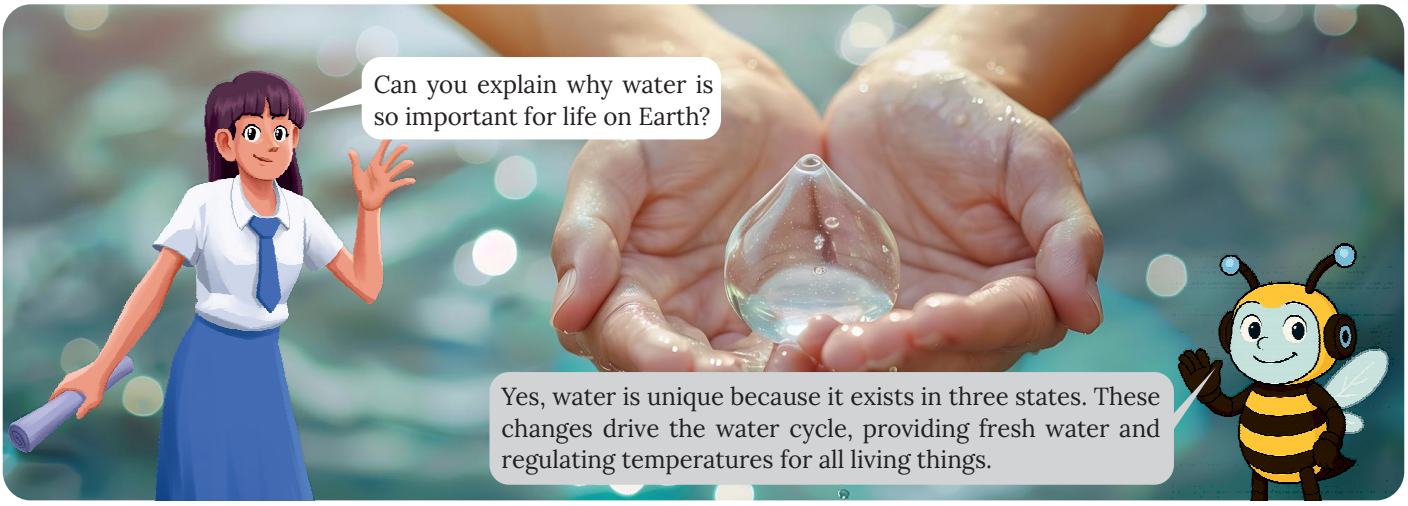
- **Factors Affecting the Rate of Evaporation**
  1. Temperature
  2. Surface Area
  3. Wind Speed
  4. Humidity
- **How Do Clouds Give Us Rain?**
  - ✓ Evaporation → Water vapor rises into the atmosphere
  - ✓ Condensation → Water vapor cools and condenses into droplets
  - ✓ Cloud Formation → Droplets gather, forming clouds
  - ✓ Precipitation → When droplets combine and become heavy, they fall as rain
- **The Water Cycle**



Transformation of Water States

- **Melting**
  - ✓ Ice turning into water when heated above 0°C
- **Freezing**
  - ✓ Water turning into ice below 0°C
- **Condensation**
  - ✓ Water vapor cooling and turning into liquid
- **Sublimation**
  - ✓ Transition from solid (ice) directly to gas (vapor) without becoming liquid





In Focus

- The Science of Water
- Evaporation and Its Role in Nature
- Transformation of Water States

Introduction

Water, an essential component of life, exists in three primary states: solid, liquid, and gas. This journey between states is driven by changes in temperature and pressure, showcasing the fascinating dynamics of matter. In its solid form as ice, water provides stability in polar regions. As a liquid, it sustains life through rivers, lakes, and oceans. In its gaseous state as vapor, it contributes to the water cycle, forming clouds and returning to Earth as rain. Processes like melting, freezing, evaporation, and condensation demonstrate the constant transformation of water in nature. This cycle not only maintains ecological balance but also inspires innovations in science and daily life.

From History's Pages

Water is believed to have been present on Earth since its early formation, around 4.8 billion years ago. During the planet's initial stages, Earth was extremely hot, and water existed primarily in its gaseous form. As the surface began to cool about 3.8 billion years ago, the water vapor condensed into liquid form, resulting in rainfall. This rain accumulated and eventually formed the oceans, covering much of the planet's surface. Earth's atmosphere, which originally lacked water, became enriched with it as the planet cooled. The presence of water was crucial in shaping Earth's geology and climate. Oceans formed the foundation for the development of early life. The cooling process also allowed for the stabilization of temperatures, making Earth more conducive to life.

The Science of Water

Water is vital for all living organisms, including humans, as it supports essential daily activities like drinking, cooking, and cleaning. It is one of the most abundant and indispensable compounds on Earth. At room temperature, water is a tasteless and odorless liquid capable of dissolving a wide variety of substances, making it a universal solvent.

Approximately 97.5% of the Earth's water is found in oceans, which cover about 70% of the planet's surface. However, this vast quantity of water is saline and unsuitable for human use. Freshwater accounts for only 2.5% of the total water on Earth, with 68.9% of it stored in ice caps, 30.8% as groundwater, and merely 0.3% in lakes and rivers. This scarcity of accessible freshwater highlights the critical need for conserving water to ensure its availability for future generations.

Water Distribution on Earth	Percentage	Details
Total water in oceans	97.5%	Covers 70% of Earth's surface; saline
Freshwater	2.5%	Suitable for human use; limited supply
Stored in ice caps	68.9%	Largest freshwater reserve
Stored as groundwater	30.8%	Underground water
Stored in lakes and rivers	0.3%	Easily accessible freshwater

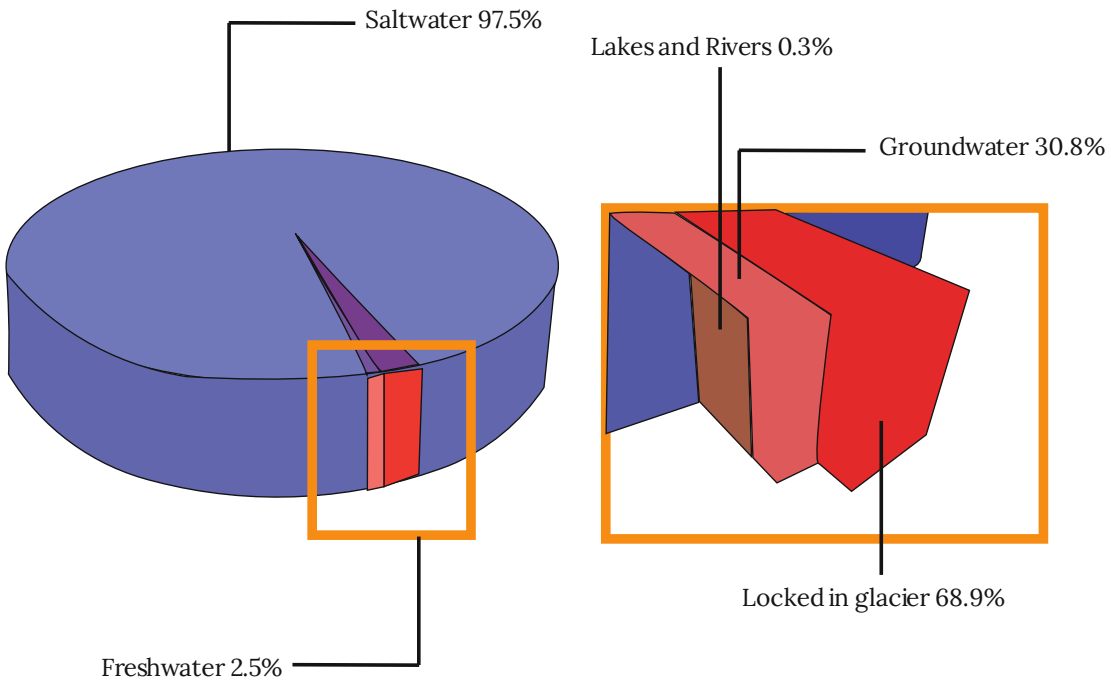


Fig. 8.1 Water Distribution on Earth

States of Water

All substances, including water, are made up of molecules. The way these molecules are arranged and held together determines their state of matter. Water exists in three states: solid, liquid, and gas. These states differ due to the unique arrangement of molecules in each state.

In all states of water, there is a space between the molecules, referred to as intermolecular or interparticle space. Additionally, molecules exert an attraction toward each other, called intermolecular force of attraction. The **cohesive force**, a specific type of **intermolecular attraction**, refers to the force of attraction between particles of the same kind. The balance between intermolecular force of attraction and intermolecular space plays a crucial role in determining the state of matter.

The states of water, classified based on molecular arrangement, are solid, liquid, and gas, each with distinct properties arising from the organization of molecules.

Keywords

Cohesive Force: It is the force of attraction between molecules of the **same substance**. It helps substances like water form droplets or maintain their shape.
Intermolecular Attraction: It refers to the **forces of attraction or repulsion between molecules** in a substance.

Solid (Ice)

- In the solid state, water appears as ice or frost. When water cools and solidifies, it takes on this form.
- This occurs when water is exposed to low temperatures.
- The molecules in ice are tightly arranged in a fixed structure.
- Ice has a defined shape and fixed volume.

Liquid (Water)

- In the liquid state, water flows freely and exists as a fluid.
- This state occurs under normal conditions, such as room temperature.
- The molecules in liquid water are loosely packed, allowing them to move around.
- However, it retains a fixed volume and can flow or spread easily.

Gas (Water Vapor)

- In the gaseous state, water exists as steam or water vapor.
- This transformation happens when water boils or evaporates.
- The molecules in water vapor are widely spaced, allowing them to move freely.
- Water vapor has neither a fixed shape nor a fixed volume.

Ice

Water

Water Vapor

Fig. 8.2 States of Water

State of Water	Description	Shape	Volume	Molecular Arrangement
Solid (Ice)	Exists as ice or snow when water cools.	Fixed shape	Fixed volume	Closely packed, minimal movement
Liquid (Water)	Free-flowing liquid at room temperature.	Takes container's shape	Fixed volume	Loosely packed, moderate movement
Gas (Water Vapour)	Exists as water vapor or steam when water boils.	No fixed shape	No fixed volume	Far apart, rapid movement

Fact Flash

Did you know that water is the only common substance on Earth that naturally exists in all three states – solid, liquid, and gas – within the typical range of temperatures found on our planet? This unique property is vital for supporting life!

Common Misconceptions

× **Misconception:** Water molecules break apart when water boils.

✓ **Correction:** When water boils, the molecules (H_2O) themselves do not break apart. Instead, they gain enough energy to break free from their liquid bonds and become gaseous water vapor.

× **Misconception:** Steam is visible..

✓ **Correction:** True steam (water vapor) is an invisible gas. The white "steam" we see from a kettle or hot spring is actually tiny liquid water droplets formed when the hot, invisible water vapor immediately cools and condenses in the air.

Science Around You

Water is a fundamental chemical compound with the formula H_2O, meaning each molecule contains two hydrogen atoms and one oxygen atom. Its simple structure belies its extraordinary properties. Water is known as the "universal solvent" because it can dissolve more substances than any other liquid, which is crucial for biological and geological processes. Its high specific heat capacity means it can absorb a lot of heat without a large temperature change, helping to moderate Earth's climate. Furthermore, unlike most substances, water expands when it freezes, meaning ice is less dense than liquid water, allowing ice to float and insulate aquatic life in cold climates. Understanding these properties is essential to grasp life on Earth.

Activity

Observing Water's States Objective: To observe and identify water in its three states of matter.

- **Materials Required:** Ice cubes in a bowl, A glass of tap water, A kettle or pot with water (and a heat source), A cold metal plate or mirror, Safety gloves (for handling hot kettle)
- **Procedure:**
  1. **Solid State:** Examine the ice cubes in the bowl. Note their fixed shape and hardness. Touch one briefly to feel its coldness.
  2. **Liquid State:** Observe the glass of tap water. Notice how it flows and takes the shape of the container.
  3. **Gaseous State (Part 1 - Invisible Vapor):** Carefully boil water in the kettle. Observe the immediate area above the spout. You might notice a short gap where nothing is visible before the "steam" appears. This gap is where the invisible water vapor is.
  4. **Gaseous State (Part 2 - Condensation):** Hold the cold metal plate or mirror a few inches above the "steam" (the visible white cloud) coming from the kettle.
  5. **Observe:** Note and describe what forms on the cold plate.

Fig. 8.3 Materials Required

- **Observation:** Observe that ice has a fixed shape, liquid water flows, and an invisible gas exists before condensing into visible droplets on a cold surface.

Knowledge Checkpoint

Gap Analyzer™ Homework

Watch Remedial

Remembering

Understanding

Applying

Analyzing

Multiple Choice Questions:

1. The chemical formula for water is:

   a) CO_2 ☐ b) H_2O ☐ c) O_2 ☐ d) N_2 ☐

2. The invisible gas formed when water heats up is called:

   a) Steam ☐ b) Fog ☐

   c) Water vapor ☐ d) Mist ☐

3. Which property of water allows ice to float on liquid water?

   a) Its high boiling point ☐ b) Its ability to dissolve many substances ☐

   c) Solid ice is less dense than liquid water ☐ d) Its freezing point is 0°C ☐

Short Answer Question:

4. Name the gaseous form of water that is present in the air.
5. Which form of water is most commonly found in oceans, rivers, and lakes?

Long Answer Question:

6. Describe the characteristics of ice, water, and water vapor. Give one example where each form is found in nature.

Evaporation and Its Role in Nature

Evaporation is the process by which a liquid changes into a gas, typically at the surface of the liquid. It occurs when molecules gain enough energy to overcome intermolecular forces and escape into the air as vapor. This process plays a vital role in nature, such as in the water cycle, where it helps form clouds and regulates temperature. Evaporation is also used in everyday activities like drying clothes and cooling drinks.

Several factors influence the speed of evaporation, including:

- The surface area of the liquid exposed to air
- The surrounding temperature
- The presence of wind or air movement
- The level of humidity in the atmosphere

Cooling Effect

The cooling effect is a natural phenomenon that occurs when evaporation absorbs heat, leading to a reduction in temperature. A traditional example is the matka (clay pot), often found in villages. Unlike stainless steel containers, water stored in a matka remains cooler due to its porous surface. Water seeps through the pores of the clay and evaporates, absorbing heat from the surroundings and cooling the water inside the pot. This natural cooling system has been used for centuries in rural areas to keep drinking water cool without the need for refrigeration.

Another example of the cooling effect can be observed with hand sanitizers. When sanitizer is applied to the skin, the alcohol present in it evaporates quickly, drawing heat away from the skin and creating a cooling sensation. This principle is an everyday demonstration of how evaporation contributes to temperature reduction.

Factors Affecting the Rate of Evaporation

Factor	Effect on Evaporation	Explanation/Examples
Surface Area	Larger surface area = Faster evaporation	More molecules are exposed to air, increasing the chance of escape as vapor.
		Example: Water on a flat plate evaporates faster than water in a small bottle cap.
Temperature	Higher temperature = Faster evaporation	Increased temperature provides energy to molecules, helping them overcome intermolecular forces.
		Example: Water evaporates faster under the sun compared to shade; clothes dry quickly on hot, sunny days.
Wind	Stronger wind = Faster evaporation	Wind removes water vapor from the liquid's surface, preventing saturation and allowing continuous evaporation.
		Example: Clothes dry faster on a windy day compared to a calm day.
Humidity	Higher humidity = Slower evaporation	Air saturated with water vapor has less capacity to hold more, reducing the evaporation rate.
		Example: Clothes take longer to dry on rainy days due to higher humidity in the atmosphere.

How Do Clouds Give Us Rain?

The formation of rain is directly linked to the process of condensation, which is critical for returning water vapor back to the Earth's surface. This process begins when warm, moist air rises and cools as it moves to higher altitudes. As the air cools, it reaches a point where it can no longer hold water vapor, causing the vapor to condense into tiny water droplets. These droplets often form around dust particles, creating the clouds that float in the sky.

As more droplets merge, they form larger and heavier water droplets. When these droplets grow large enough, they overcome the upward air currents and fall to the ground as precipitation. Depending on atmospheric conditions, precipitation can occur as rain, hail, or snow.

The Water Cycle

The water cycle is a continuous process that connects the Earth's air, clouds, oceans, lakes, plants, animals, and glaciers. This cycle ensures the movement and balance of water throughout the planet. The water cycle involves several key steps:

- **Evaporation:** The sun's heat converts water from oceans, rivers, and lakes into water vapor. This vapor rises into the atmosphere, initiating the cycle.
- **Transpiration:** Plants play a role in the water cycle by releasing water vapor through their leaves, a process known as transpiration. This contributes significantly to the amount of moisture in the atmosphere.

- **Condensation:** As warm air carrying water vapor rises to higher altitudes, it cools. The cooler air cannot hold as much moisture, leading to the condensation of water vapor into tiny droplets, which form clouds.
- **Precipitation:** Clouds form when condensed droplets combine and grow in size. Once these droplets become heavy enough, they fall to the Earth as rain, hail, or snow, depending on temperature and other atmospheric conditions. Precipitation is vital for replenishing freshwater on land.
- **Runoff:** Rainfall and melting snow create runoff, where water travels across the Earth's surface, filling rivers, lakes, and eventually returning to oceans. This process completes the cycle and ensures the redistribution of water.

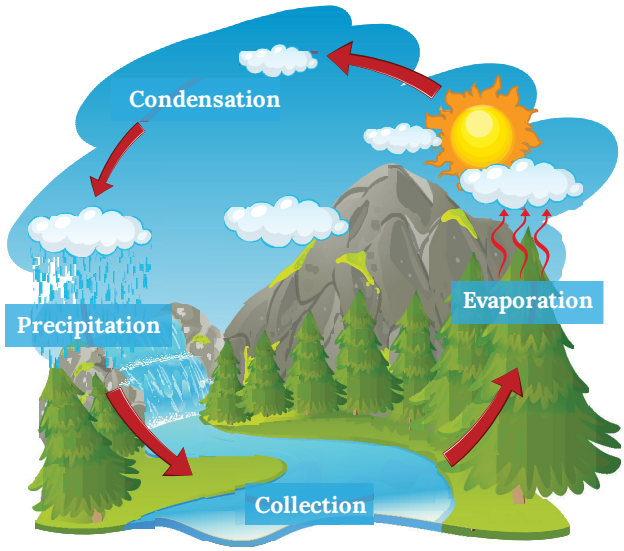


Fig. 8.4 Water Cycle

The Importance of the Water Cycle

The water cycle is one of the most important natural processes on Earth because it maintains the balance of water between the atmosphere, land, and oceans. Through processes like evaporation, condensation, and precipitation, water keeps moving in a continuous cycle, shaping our weather patterns and making life possible. Without this cycle, rivers, lakes, and groundwater would eventually dry up, leaving humans, animals, and plants without fresh water. It is also important to remember that although the Earth has plenty of water, only a tiny fraction is fresh and usable, as most of it is stored in the salty oceans or locked in glaciers and ice caps.

Fact Flash

A single tree can release hundreds of liters of water vapor into the air every day through a process called transpiration. This is similar to evaporation, but it happens from the tiny pores in plant leaves. When millions of trees in a forest transpire together, they add an enormous amount of moisture to the atmosphere, which helps in forming clouds and even bringing rainfall. In fact, this is one reason why forests are often called the "lungs of the Earth"—they not only give us oxygen but also play a big role in maintaining the water cycle and climate balance.

People's Movement: Narmada Bachao Andolan


Fig. 8.5 Phto Credit: AFP

- *Began in the 1985 across Madhya Pradesh, Maharashtra, and Gujarat.*
- *Led by Medha Patkar with support from Baba Amte.*
- *Opposed large dams like the Sardar Sarovar Dam on the Narmada River.*
- *Highlighted issues of displacement of people, deforestation, loss of farmland, and damage to ecosystems.*
- *Stressed the need for sustainable water use and fair rehabilitation for affected families.*
- *Today, it remains a symbol of people's fight for environmental justice and responsible development.*

With the growing global population, the demand for water has risen sharply, putting great pressure on rivers, lakes, and groundwater. Many parts of the world already suffer from water scarcity due to overuse, wastage, and poor management. The lessons of the NBA remind us that development must always be balanced with people's needs and ecological safety. We can contribute by fixing leaks, reusing water, practicing rainwater harvesting, planting trees, and using water wisely. Saving water ensures enough supply for humans, animals, and plants, while also keeping the ecological balance intact.

Common Misconceptions

× **Misconception:** Evaporation only happens when water is boiling.

✓ **Correction:** Evaporation occurs at all temperatures, even below the boiling point. Boiling is a specific type of evaporation where bubbles form throughout the liquid.

× **Misconception:** Evaporation makes things cold.

✓ **Correction:** Evaporation causes a cooling effect on the remaining liquid because the highest-energy molecules escape, leaving behind lower-energy (cooler) ones. The process itself absorbs heat from the surroundings.

Science Around You

Evaporation is a continuous and natural process where liquid water transforms into an invisible gas called water vapor, rising into the atmosphere. This transformation occurs as water molecules on the surface gain enough energy, typically from the Sun's heat, to break away from the liquid and become airborne. Evaporation happens at all temperatures, from puddles slowly disappearing on a cloudy day to vast amounts of water rising from oceans. It's a fundamental part of the Earth's water cycle (or hydrological cycle), which constantly redistributes water around the globe. This process not only forms clouds and eventually leads to precipitation but also helps regulate Earth's temperature by absorbing significant amounts of heat.

Activity

Factors Affecting Evaporation

- **Objective:** To investigate how different factors affect the rate of evaporation.
- **Materials Required:** Three identical shallow plates, Water, A fan or hairdryer, A warm, sunny spot
  A cool, shady spot, Two shallow plates: one in sun, one in shade / one with fan, one without
- **Procedure:**
  1. **Experiment (Temperature):** Pour an equal amount of water into two identical plates. Place one plate in a warm, sunny spot and the other in a cool, shady spot.
  2. **Experiment (Air Movement):** Pour an equal amount of water into two identical plates. Place one plate in front of a fan (or use a hairdryer on a cool setting) and the other in a still air location.

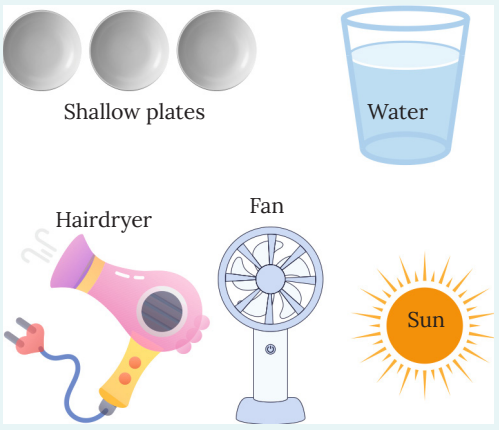


Fig. 8.6 Materials Required

  3. **Observe:** Check the plates periodically (e.g., every 30 minutes) and note which plate's water evaporates faster in each experiment.
- **Observation:** Notice how increased temperature and increased air movement lead to a faster rate of water evaporation.

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering

Multiple Choice Questions:

1. Evaporation is the process where liquid water changes into:

   a) Ice ☐ b) Clouds ☐ c) Water vapor ☐ d) Rain ☐

Understanding

2. Which of these provides the primary energy for evaporation in the water cycle?

   a) Earth's core ☐ b) Moon's gravity ☐ c) The Sun ☐ d) Wind ☐

3. If you want wet clothes to dry faster, which factor related to evaporation would you try to increase?

   a) Humidity ☐ b) Temperature ☐ c) Pressure ☐ d) Cloud cover ☐

Short Answer Question:

Applying

4. In your own words, what is evaporation?
5. Briefly explain why evaporation is considered a crucial part of the water cycle.

Long Answer Question:

Evaluating

6. Describe how evaporation contributes to cooling on Earth and in living organisms. Provide two distinct examples (e.g., sweating, wet cloth drying) where this cooling effect is noticeable and explain the scientific principle behind it.

Transformation of Water States

Water can transition between its three states—solid, liquid, and gas—by adding or removing heat energy. When heat is applied, the molecules in water move more rapidly, breaking free from their bonds and causing a change in state, such as ice melting into water or water evaporating into vapor. Conversely, removing heat slows down molecular movement, leading to condensation or freezing. This process demonstrates that the three states of matter are interconvertible through the application or removal of heat.

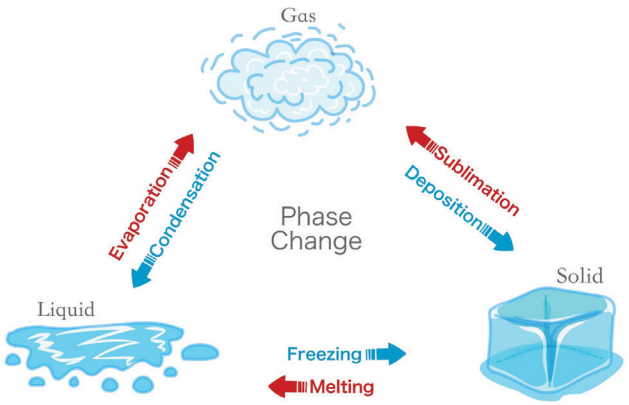


Fig. 8.7 Transformation of Water States

Melting

Melting is the process by which a solid changes into its liquid state upon absorbing heat energy. When ice is kept at room temperature, it absorbs heat from its surroundings. This added energy increases the movement of the molecules, causing them to vibrate more rapidly. As the molecules continue to gain energy, they reach a point where the heat overcomes the intermolecular forces holding them together.

Fig. 8.8 Melting

At this stage, the tightly packed structure of the solid breaks apart, and the molecules start to move more freely. The ice transforms into liquid water, marking the completion of the melting process. Melting demonstrates how energy can alter the state of matter by reducing the intermolecular forces. It is a natural phenomenon essential in various processes, from the water cycle to everyday life activities.

Freezing or Solidification

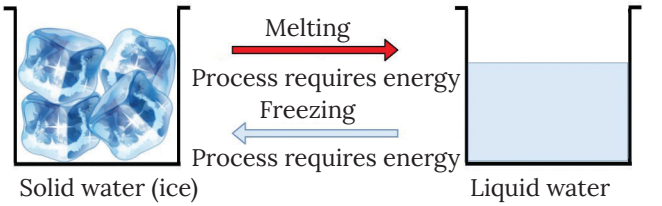


Fig. 8.9 Freezing

Freezing, also known as solidification, is the process by which a liquid turns into a solid when its temperature is lowered. When water is placed in a freezer, it gradually loses heat. This loss of heat reduces the energy of water molecules, causing them to move more slowly. As the molecular movement slows down, the molecules come closer together and start forming rigid bonds. Eventually, their movement becomes so restricted that water transitions into ice, forming a solid structure. This entire process occurs because the freezing point is reached, where water no longer remains a liquid. Solidification is a natural phenomenon observed in many substances and is an important part of the water cycle, as it forms ice in polar regions and during winter.

Vaporisation

Vaporisation is the process by which a liquid transforms into its gaseous or vapor state. This process can occur in two distinct ways: evaporation and boiling.

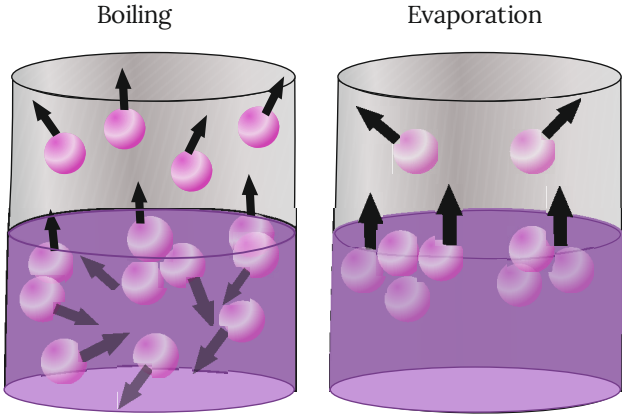


Fig. 8.10 Boiling and Evaporation

- **Evaporation:** Evaporation is a gradual process that occurs at all temperatures. It happens when molecules at the surface of a liquid absorb heat energy from their surroundings, enabling them to escape into the air as vapor. For example, when water absorbs heat from its environment, it transforms into water vapor or steam. This is why clothes dry in the open air, even without boiling temperatures.
- **Boiling:** Boiling is a more rapid process that occurs when a liquid is heated to its boiling point. At this stage, the molecules gain enough heat energy to overcome intermolecular forces and move farther apart. Once the temperature reaches a critical level, the liquid molecules leave the surface and turn into vapor or steam. This transformation of a liquid into its gaseous state at a specific temperature is known as boiling.

Both evaporation and boiling highlight the fascinating ability of liquids to change states when sufficient heat energy is applied.

Condensation

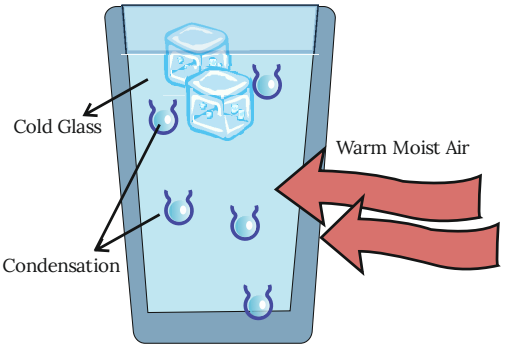


Fig. 8.11 Condensation

Condensation is the process through which a gas turns into a liquid when it is cooled. As the gas cools, its molecules lose energy and begin to move more slowly. Over time, the reduced energy and movement bring the molecules closer together, allowing them to transition into a liquid state. This natural process is vital in phenomena like cloud formation, dew, and the cooling of steam into water. Condensation plays a key role in the water cycle and various industrial applications.

When you place ice in a glass of juice, you may notice tiny droplets of water forming on the outer surface of the glass. This occurs because the cold surface of the glass cools the surrounding air, causing the water vapor present in the air to condense into liquid droplets. This process is known as condensation. The

Fact Flash

Did you know that the precise melting and boiling points of water were fundamental to establishing our modern temperature scales? In the early 1700s, scientists like Gabriel Fahrenheit used water's distinct transitions to define the fixed points on his thermometer, a crucial step in standardizing temperature measurement!

amount of water vapor present in the air is referred to as humidity. Higher humidity means more water vapor in the air, making condensation more likely when the air comes into contact with cooler surfaces.

Sublimation

Sublimation is the process where a solid changes directly into a gas without becoming a liquid. In the case of water, ice or snow can turn straight into water vapor without melting. This usually happens in very cold and dry places, like polar regions or high mountains. For example, ice cubes kept in a freezer slowly shrink even though they don't melt, and clothes in freezing weather can dry because the ice on them changes directly into vapor. Sublimation is also important in the water cycle of cold regions, as it helps send water vapor back into the atmosphere.

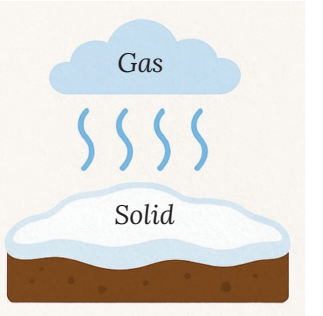


Fig. 8.12 Sublimation

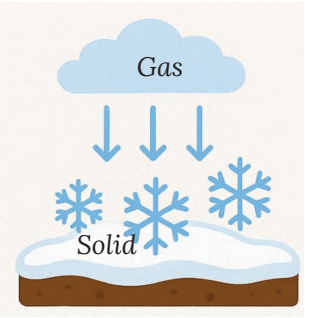


Fig. 8.13 Deposition

Deposition

Deposition is the reverse of sublimation. It is the process where a gas changes directly into a solid without becoming a liquid. For water, deposition happens when water vapor in the air turns directly into ice. A common example is frost forming on grass, leaves, or car windows on a winter morning. Snowflakes in the clouds are also formed by deposition when water vapor changes into ice crystals high up in the sky. This process is important in cold regions as it keeps surfaces icy and also causes cracks in rocks to widen when frost forms inside them.

Common Misconceptions

× **Misconception:** Boiling and evaporation are the same process.

✓ **Correction:** Evaporation occurs at the surface of a liquid at any temperature. Boiling is a much more rapid process where liquid turns to gas throughout the liquid, occurring only at a specific temperature (the boiling point).

× **Misconception:** When water freezes, it just gets colder.

✓ **Correction:** When water freezes, it undergoes a fundamental change in state. Its molecules arrange into a rigid, crystalline structure, becoming a solid, and a specific amount of heat is released into the surroundings.

Science Around You

Water's unique ability to shift between its solid, liquid, and gaseous forms is a continuous and energy-driven process known as **phase change** or state transformation. These changes occur due to the absorption or release of thermal energy (heat). When water absorbs heat, its molecules gain energy and move more freely: **melting** occurs when solid ice turns into liquid water, and **evaporation** or **boiling** occurs when liquid water turns into a gas (water vapor). Conversely, when water releases heat, its molecules slow down and become more organized: **freezing** occurs when liquid water becomes solid ice, and **condensation** happens when water vapor turns back into liquid water. Less common, but still important, are **sublimation** (solid directly to gas, like drying snow) and **deposition** (gas directly to solid, like frost).

Activity

Observing Water's Transformations

- **Objective:** To directly observe melting, freezing, and condensation of water.
- **Materials Required:** Ice cubes (from a freezer), Two clear glasses, Tap water, Hot water (from a kettle/tap, but not boiling rapidly), A freezer compartment, A watch or timer, Three glasses: one with melting ice, one in freezer, one showing condensation

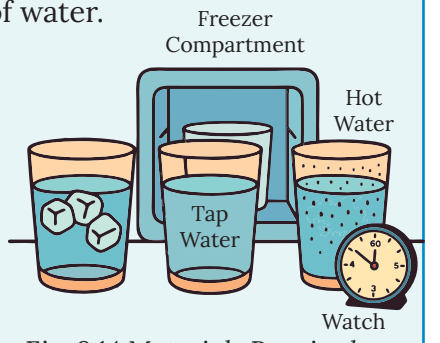


Fig. 8.14 Materials Required

- **Procedure:**
  1. **Melting (Solid to Liquid):** Place an ice cube in one clear glass at room temperature. Observe it over several minutes. Note its change in form.
  2. **Freezing (Liquid to Solid):** Fill a second clear glass halfway with tap water. Place this glass carefully into a freezer compartment. Check it after 1-2 hours (or until solid).
  3. **Condensation (Gas to Liquid):** Pour some hot (not vigorously boiling) water into the third clear glass. After about 30 seconds, hold a cold, empty glass or a cold metal spoon just above the rim of the glass with hot water.
  4. **Observe:** Note and describe the changes in the water (or water vapor) in each step.
- **Observation:** Observe the ice changing from solid to liquid, liquid water changing to solid ice, and invisible water vapor turning into visible liquid droplets on a cold surface.

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering | Understanding | Applying | Analyzing

Multiple Choice Questions:

1. What process occurs when liquid water turns into solid ice?
   a) Melting ☐ b) Evaporation ☐ c) Freezing ☐ d) Condensation ☐
2. When water changes from a liquid to a gas, it must:
   a) Release heat ☐ b) Absorb heat ☐ c) Remain at 0°C ☐ d) Become denser ☐
3. If you see frost forming on a window on a cold morning, what phase change is occurring?
   a) Melting ☐ b) Evaporation ☐ c) Sublimation ☐ d) Deposition ☐

Short Answer Question:

4. What is the main difference between evaporation and boiling?
5. Explain why water vapor turns into liquid droplets when it touches a cold surface.

Long Answer Question:

6. Describe the complete cycle of water transformations, including melting, freezing, evaporation, and condensation, and provide one real-world example where this transformation is seen.

SUMMARY

Water, a vital component of life, exists in three primary states: solid, liquid, and gas. These states depend on temperature and pressure changes, showcasing the dynamic nature of water. Water's ability to transform between states plays a crucial role in natural processes like the water cycle, maintaining ecological balance, and supporting life.

The Science of Water

Water is indispensable for daily activities like drinking, cooking, and cleaning. It is a universal solvent due to its ability to dissolve a wide range of substances. However, 97.5% of Earth's water is saline, leaving only 2.5% as freshwater, most of which is locked in ice caps and underground reservoirs.

States of Water

Water's states—solid, liquid, and gas—are determined by molecular arrangement, intermolecular forces, and space.

Solid (Ice):

- Molecules are tightly packed, giving ice a fixed shape and volume.
- Ice cannot flow or spread.

Liquid (Water):

- Molecules are loosely packed, allowing water to flow freely.

Gas (Water Vapor):

- Molecules are widely spaced and move freely.

Cooling Effect

Evaporation absorbs heat, causing a cooling effect. Examples include:

- **Matka (Clay Pot):** Water evaporates through the clay, cooling the contents.
- **Hand Sanitizers:** Alcohol evaporates quickly, cooling the skin.

The Water Cycle

The water cycle illustrates the continuous movement of water between Earth's surface and the atmosphere.

Steps Involved:

- **Evaporation:** Sun's heat converts water into vapor.
- **Transpiration:** Plants release water vapor into the air.

Transformation of Water States

Water transitions between states through the application or removal of heat:

- **Melting:** Solid turns into liquid when heat breaks intermolecular forces. Example: Ice melting into water.
- **Freezing:** Liquid turns into solid as molecular movement slows due to cooling. Example: Water freezing into ice.
- **Condensation:** Gas turns back into liquid as molecules lose energy. Example: Steam condensing on a cold surface.

Example Based Questions

Multiple Choice Questions

1. **Which process is responsible for the drying of wet clothes under the sun?**

   (a) Condensation (b) Freezing

   (c) Evaporation (d) Melting

   Answer: (c) Evaporation

   Explanation: When the Sun heats water present in clothes, it slowly changes into water vapour and mixes with air. This natural process is evaporation, which helps in drying.

2. Which of the following is a correct example of condensation?

   (a) Ice melting in a glass

   (b) Water drops forming on the outside of a cold bottle

   (c) Clothes drying in the wind

   (d) Formation of snow in mountains

   Answer: (b) Water drops forming on the outside of a cold bottle

   Explanation: The cold bottle cools water vapour in the surrounding air, turning it back into liquid drops. This is condensation—the reverse of evaporation.

Short Answer Questions

4. **Why do we see water droplets on the outside of a glass filled with ice-cold water?**

   Answer: The air around the glass contains invisible water vapour. When warm air touches the cold surface of the glass, it cools down. The vapour then changes into tiny drops of water on the glass surface. This process is called condensation. It shows how air always carries water in gaseous form.

5. **Explain why we sprinkle water on the ground during summer afternoons in villages.**

   Answer: When water is sprinkled, it quickly evaporates by absorbing heat from the ground and surrounding air. This reduces the temperature and gives a cooling effect. Evaporation is a natural method of cooling, which is why sprinkling water is a common practice in hot areas.

6. **A tray of water is placed under a fan and under the Sun. In which case will evaporation be faster? Why?**

   Answer: Evaporation will be faster under the Sun, because sunlight provides more heat energy to water molecules, helping them escape as vapour. However, a fan also speeds up evaporation by blowing away humid air and replacing it with dry air. The fastest evaporation happens when both heat and airflow are present.

Long Answer Questions

7. **Explain with examples how water changes its states in nature. Why is this process important for life on Earth?**

   Answer: Water exists in three states—solid (ice), liquid (water), and gas (vapour)—and it keeps changing from one form to another:

1. **Melting:** Ice changes into liquid water when heated. Example: Ice cubes melting in a glass of juice.
2. **Freezing:** Water changes into ice on cooling. Example: Water in a freezer turning into ice.
3. **Evaporation:** Water turns into vapour when heated. Example: Drying of clothes in sunlight.
4. **Condensation:** Vapour changes back into liquid. Example: Formation of clouds.
5. **Sublimation (rare in daily life):** Ice directly changing into vapour under special conditions.

Importance:

- These changes form the water cycle, which recycles water on Earth.
- They help in rain formation, maintaining rivers and lakes.
- They regulate climate and temperature.

Thus, transformations of water states are essential for life, agriculture, and the environment. Without them, Earth would not have a balanced water supply.

Gap Analyzer™
Complete Chapter Test

EXERCISE

A. Choose the correct answer.

1. Which process is responsible for the transformation of water into vapor?
   (a) Melting ☐ (b) Condensation ☐
   (c) Evaporation ☐ (d) Freezing ☐
2. What happens to the molecules of water during freezing?
   (a) They move faster ☐ (b) They form rigid bonds ☐
   (c) They spread apart ☐ (d) They evaporate ☐
3. Why do clothes dry faster on a windy day?
   (a) Wind cools the clothes ☐ (b) Wind increases evaporation ☐
   (c) Wind decreases humidity ☐ (d) Wind removes heat from the clothes ☐
4. Which of the following is not a part of the water cycle?
   (a) Precipitation ☐ (b) Evaporation ☐
   (c) Transpiration ☐ (d) Combustion ☐
5. What is the driving force behind the water cycle?
   (a) Gravity ☐ (b) Wind ☐
   (c) The sun ☐ (d) Oceans ☐

B. Fill in the blanks.

1. Water changes from liquid to gas through the process of _____.
2. During condensation, water vapor turns into _____.
3. The sun provides heat energy that powers the process of _____ in the water cycle.
4. Plants release water vapor into the air through _____.
5. The process by which water travels across the Earth's surface as streams and rivers is called _____.

C. Write True or False.

1. Evaporation occurs only at boiling temperatures. ____
2. Condensation leads to the formation of clouds in the atmosphere. ____
3. Higher humidity speeds up the process of evaporation. ____
4. Water vapor turning into liquid droplets is an example of condensation. ____
5. Freezing involves the removal of heat energy from water. ____

D. Define the following terms.

1. Evaporation
2. Condensation
3. Precipitation
4. Transpiration
5. Water Cycle

E. Match the columns.

	Column A		Column B
1.	Evaporation	(a)	Release of vapour by plants
2.	Condensation	(b)	Water falling as rain
3.	Precipitation	(c)	Gas to liquid
4.	Freezing	(d)	Liquid to gas
5.	Transpiration	(e)	Formation of solid ice

F. Assertion and Reason

Instructions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is NOT the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

e) Both A and R are false.

1. **Assertion:** The white cloud seen from a boiling kettle is invisible water vapor.
   Reason: True water vapor is an invisible gas that condenses into visible droplets when cooled.
2. **Assertion:** Ice floats on water.
   Reason: Solid water (ice) is less dense than liquid water.
3. **Assertion:** Evaporation happens only when water boils.
   Reason: Boiling is a specific type of evaporation that occurs rapidly throughout the liquid at a fixed temperature.

G. Give reasons for the following statements.

1. Why does the rate of evaporation increase on windy days?
2. Explain why water stored in a clay pot stays cool.
3. Why is condensation important for the water cycle?
4. How does temperature influence the transformation of water between states?
5. Why does ice float on water even though it is solid?

H. Answer in brief.

1. How does evaporation contribute to the water cycle?
2. What factors affect the rate of evaporation?
3. Explain the process of cloud formation in the atmosphere.
4. How does the cooling effect occur during evaporation?
5. Why is water conservation important for sustaining life?

I. Answer in detail.

1. Explain the different stages of the water cycle and their significance.
2. Describe the processes of melting, freezing, and condensation, providing examples from daily life.
3. How do environmental factors like temperature, wind, and humidity affect evaporation?
4. Compare the characteristics of water in its three states: solid, liquid, and gas.

SKILL-BASED PRACTICE

Activity Time

STEM

Modeling the Water Cycle in a Bag

Materials Needed: A large clear sealable plastic bag (e.g., Ziploc bag), Water, A marker, Tape, Sunlight (a window or sunny spot)

Activity Steps:

1. **Add Water:** Pour about half a cup of water into the plastic bag.
2. **Mark Water Level:** Use the marker to draw a line on the bag indicating the initial water level.
3. **Seal and Tape:** Seal the bag tightly, removing as much air as possible. Tape the bag to a sunny window.
4. **Observe Daily:** Over the next few days, observe the bag at different times of the day. Look for changes inside the bag.

Materials Required

5. **Draw and Label:** On another piece of paper, draw what you observe inside the bag, labeling the processes you see (e.g., evaporation, condensation, precipitation).

Questions:

- What did you observe happening to the water at the bottom of the bag? What process is this?
- What formed on the inside walls of the bag, especially near the top? What process caused this?
- How does this model relate to the actual water cycle on Earth?

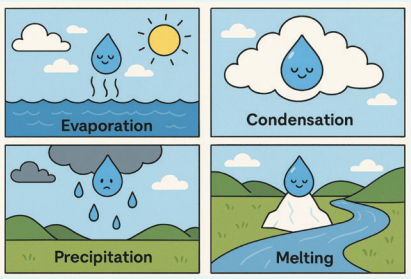
Skills Covered: Model Building, Observation, Understanding Water Cycle Processes, Scientific Inquiry

Creativity

Art

"Water's Journey" Storyboard

Create a storyboard (a series of illustrated panels) depicting a drop of water's journey through its various states and locations in the water cycle. Each panel should illustrate a key stage (e.g., evaporation from an ocean, condensation into a cloud, falling as rain, freezing into ice, melting into a river). Use captions to explain each tstage.



Water's journey

Materials to Use: Poster board or several pieces of drawing paper, Pencils, crayons, markers, or paints.

Questions:

- What was the most challenging state or process to illustrate visually? Why?
- How did you use colors and symbols to represent the different states and energy changes?
- Which part of the water's journey do you find most fascinating?

Skills Covered: Creativity, Storytelling through Art, Understanding Scientific Processes

Phase Change Investigation

Group Activity

The Disappearing Ice Cube

1. **Setup:** Each group takes three identical ice cubes.
2. **Condition (Control):** Place one ice cube on a plate in a cool, shady spot indoors.
3. **Condition (Surface Area):** Crush another ice cube into smaller pieces on a separate plate in the same cool, shady spot.
4. **Condition (Heat):** Place the third ice cube on a plate in a warm, sunny spot (e.g., direct sunlight by a window).
5. **Observe and Record:** Observe the ice cubes every 5 minutes. Record which ice cube melts the fastest and which melts the slowest. Note when each ice cube has completely melted.

Questions:

- Which ice cube melted the fastest, and which melted the slowest?
- What factors (variables) were you testing in this experiment?
- How does surface area affect the rate of melting? Explain why.
- How does temperature (heat) affect the rate of melting? Explain why.

Skills Covered: Experimental Design, Observation & Data Recording, Analysis of Variables, Teamwork

The Lakeside Cabin in Winter

Case Study

Read the given passage below and answer the question:

A family is staying at a cabin by a large lake during winter. They observe that the lake's surface is frozen solid, but fish are still alive beneath the ice. They also notice that snow on their porch seems to disappear even on very cold days when the temperature never goes above freezing.

Lakeside Cabin

Guiding Questions for Analysis:

1. Why does the ice float on the lake, protecting the fish below?
2. What process causes the snow on the porch to disappear even when the temperature is below freezing?
3. If the family brings a block of ice indoors, what process will occur as it gains heat from the room?
4. What state is the water in when it is protecting the fish, and what state is the snow in when it disappears?
5. What state of water would form if the air inside the warm cabin became very humid and then touched a very cold window pane?

Skills Covered: Classification, Analysis, Teamwork, Communication, Scientific Investigation

The Water Cycle and Climate Change

Source Based Question

"Among the most serious Earth science issues today are the changes in the water cycle caused by climate change. Scientists agree that Earth's climate is changing because of both natural factors (like changes in the Sun) and human factors (like greenhouse gases). These changes are affecting water vapor, clouds, rainfall, and river flow. For example, warmer air makes more water evaporate, so there is more moisture in the atmosphere. This has led to more heavy rainstorms in many land areas. Because of warmer temperatures, more rain is falling instead of snow. In some places in the Northern Hemisphere, snow is melting earlier in spring, which changes the time when rivers have more water. This is causing problems because water is less available in summer and fall, when people need it most."

Changes in water runoff into rivers and streams are another expected consequence of climate change by the late 21st Century. This map shows predicted increases in runoff in blue, and decreases in brown and red.

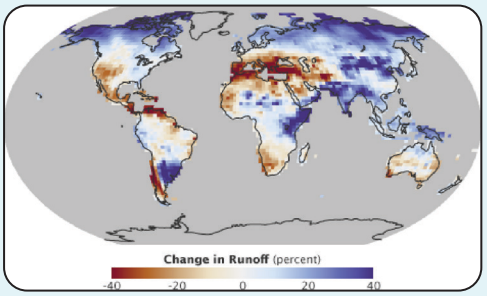


Image Credit: (Map by Robert Simmon, using data from Chris Milly, NOAA Geophysical Fluid Dynamics Laboratory.)

Questions:

1. **Evaporation & Water Vapor**
   - According to the passage, why does evaporation increase when the atmosphere becomes warmer?
   - How does this affect the amount of moisture in the air?
2. **Changes in Rivers**
   - What happens to river water flow when snow melts earlier in spring?
   - How could this cause problems for people in summer and fall?
3. **Climate & Water Cycle Link**
   - List two ways climate change is affecting the water cycle as mentioned in the passage.
   - Why do scientists think these changes are serious for society?
4. **Critical Thinking (Connect to Daily Life)**
   - Imagine your town depends on snowmelt for water. If snow melts earlier each year, what difficulties might people face?
   - Suggest one way communities could adapt to reduced fresh water in summer.

Skills Covered: Observation, Curiosity, Critical thinking, Connecting real-life observations