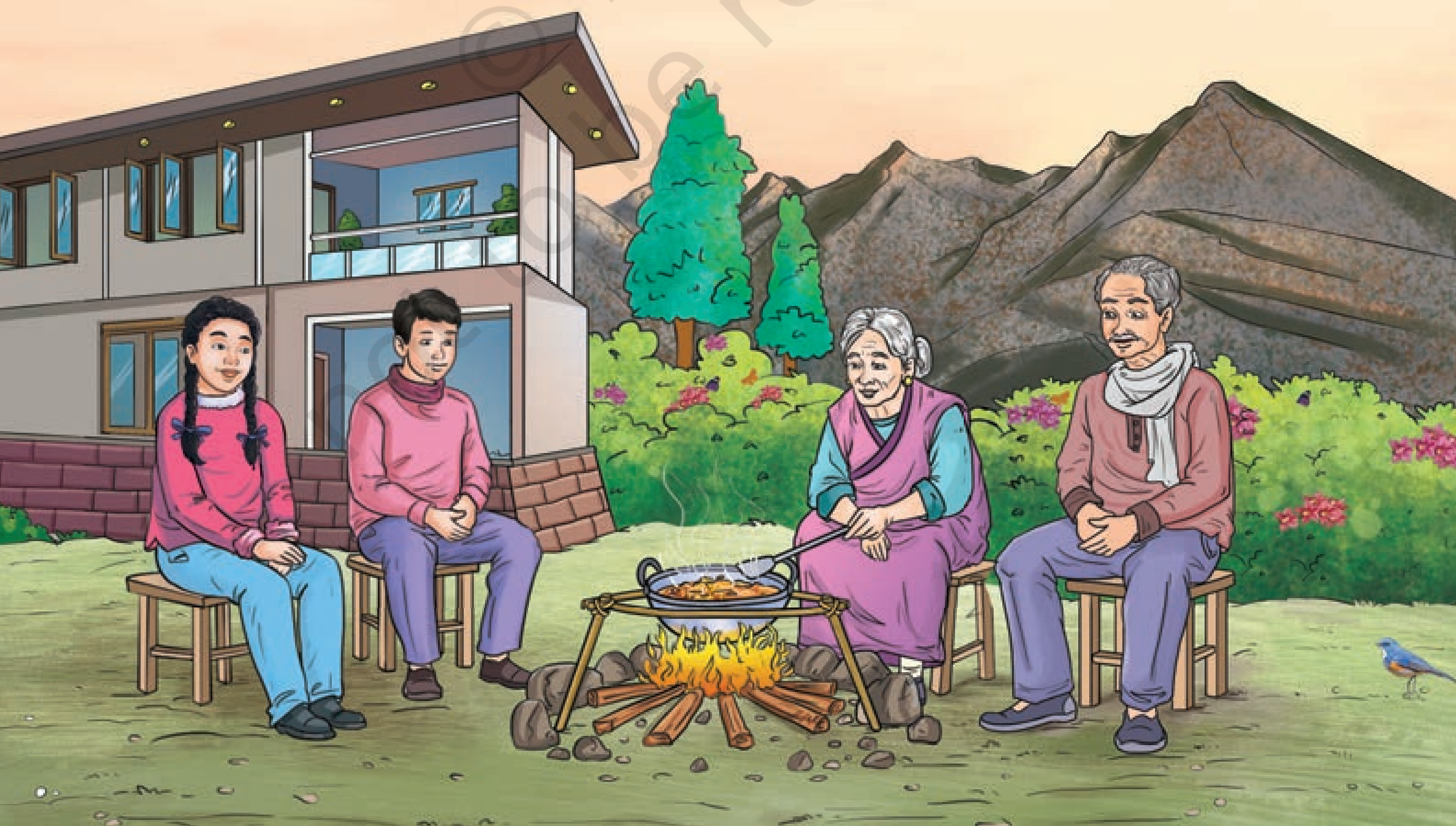
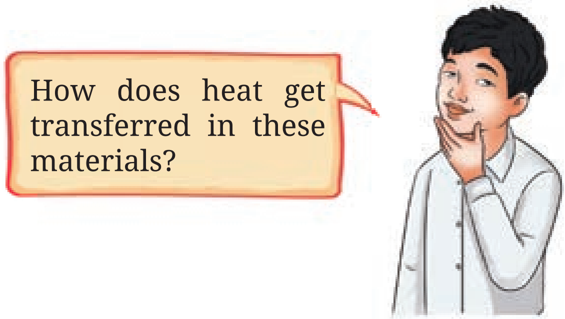
7 Heat Transfer in Nature

Pema and her brother Palden reside in Gangtok. On a cold winter evening, they are sitting around a fireplace. Palden shares his experiences of visiting Kerala during the winter vacation. He says that compared to Gangtok, winter in Kerala is comparatively warm and humid. Both Pema and Palden are curious about why some places are so cold and others quite hot.

Hearing them express their curiosity, their grandfather, a retired science teacher, says, "Kerala is closer to the equator than Sikkim and it also has a long coastline, which results in warmer and more humid weather conditions". Palden replies, "Yes, we learnt in Grade 6 Science and Social Science that for us on the Earth, the Sun is the main source of heat and light, and around the equator, the climate is generally hot".

As they are talking, Pema is keenly observing her grandmother cooking *thukpa* (a traditional Sikkimese dish) in a large metal pan. Pema asks, "Why are cooking utensils generally made of metals?" Palden immediately responds that they had studied in the chapter 'The World of Metals and Non-metals' that such materials are good conductors of heat.





Let us **perform** an activity to learn why certain materials are good conductors of heat.

7.1 Conduction of Heat

Activity 7.1: Let us experiment

Caution—This activity should be carried out under the supervision of a teacher or an adult.

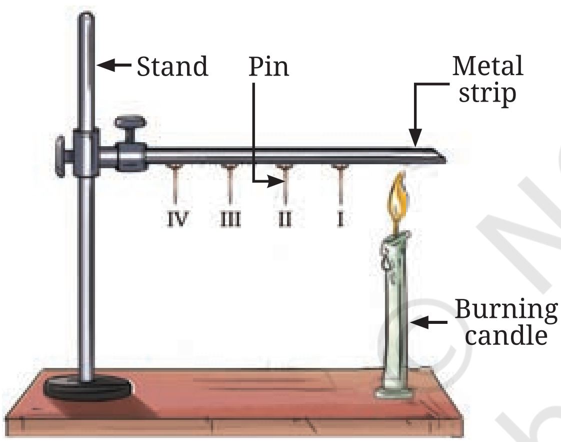


Fig. 7.1: Heat transfer in a metal strip

- Take a strip of a metal, such as aluminium or iron, about 15 cm long.
- Attach four pins to the strip with the help of wax such that they are arranged at nearly equal distances (about 2 cm apart), as shown in Fig. 7.1.
- Secure the strip to a stand and label the pins as I, II, III, and IV, as shown in Fig. 7.1. (If a stand is not available, place the strip between two bricks for support.)
- Heat the end of the strip that is away from the stand with a candle or a spirit lamp.
- What will happen to the pins? Will they remain attached to the strip or will they fall?
- **Predict** the order in which the pins will fall from the strip.
- **Record** your observations in Table 7.1.

Table 7.1: Falling of pins

Pin falling first		Reasons for what you observed
Prediction	Observation	

You **observed** that the pin closest to the candle flame (pin I) falls first, followed by pins II, III, and IV. Why does pin I fall before pin II? Why did all the pins not fall together?

From your observations, what can you **infer**? Do you think that heat is being transferred along the metal strip from the end that is being heated? As the heat travels along the strip and approaches a pin, the wax holding it melts and the pin falls. Here, the transfer of heat takes place from the hot end of the strip to the colder end. The process of heat transfer from the hotter part of an object to the colder part is called **conduction**. In this process, the particle that gets heated, passes the heat on to its neighbour, and so on. However, the particles themselves do not move from their positions.

Materials like metals that allow heat to pass through them easily are called **good conductors** of heat. Because metals are good conductors of heat, we use utensils made of metals for cooking. In solids, heat transfer takes place mainly through the process of conduction.

If we use a strip made of a material like wood or glass in place of a metal strip to perform Activity 7.1, the pins will not fall. Can you think of the reason for this based on our learning from the chapter 'The World of Metals and Non-Metals'?

Materials such as glass and wood do not allow heat to pass through them easily and are **poor conductors** (insulators) of heat. Clay and porcelain are also poor conductors of heat—that is why tea or coffee kept in such cups stays hot longer.

List some materials around you and **classify** them as good or poor conductors of heat in Table 7.2.

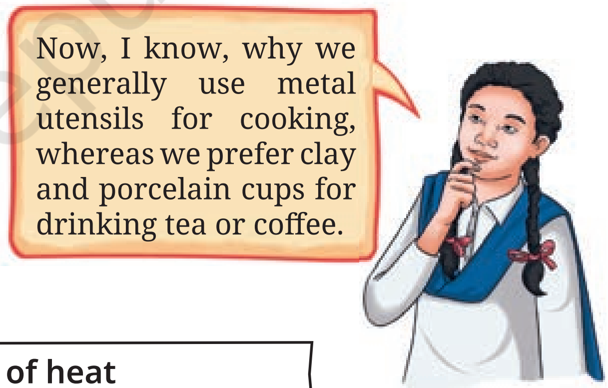


Table 7.2: List of good or poor conductors of heat

S.No.	Material	Good or Poor conductor of heat
1.	Steel	Good conductor
2.	Wood	
3.		

Does your list include air? If it is there on the list, where have you placed it?

You must have experienced that during winters, we prefer wearing woollen clothes to keep ourselves warm.

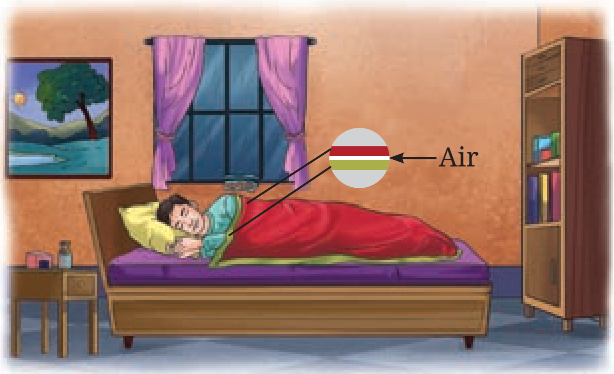


Fig. 7.2: Air trapped between two thin blankets acts as an insulator

Woollen fabric traps air in its pores and as air is a poor conductor of heat, it reduces heat flow from our bodies to our surroundings. As a result, we feel warm. Similarly, air trapped between the layers of clothing acts as a poor conductor of heat and keeps us warm. The presence of air between two thin blankets is the reason why we prefer them over one thick blanket to keep us warm (Fig. 7.2).

Is it possible to construct houses that are not affected much by the outside heat and cold? Houses constructed in places with a very hot or cold climate often use the concept of heat transfer to keep them cool or warm.

FASCINATING FACTS

The upper regions of the Himalayas, such as the Mori block of Uttarkashi in Uttarakhand, experience an extremely cold climate and heavy snowfall during winters. Houses here are often built to stay warm during winters, with walls made of two wooden layers filled with cow dung and mud between them. As wood and mud are poor conductors of heat, they prevent heat loss and help in keeping the houses warm.

There are houses with outer walls that are constructed using hollow bricks that keep them warm in winters and cool in summers. This happens because the air that gets trapped in the hollow bricks is a poor conductor of heat.

Why is the smoke going up?

Pema draws Palden's attention to the rising smoke from the burning firewood, around which they are sitting.

7.2 Convection

To understand why smoke rises, let us perform an activity.

Fig. 7.3(a): Initial set-up

Activity 7.2: Let us investigate

- Take two identical paper cups.
- Hang them using threads of equal length in an inverted position on the two ends of a wooden stick, as shown in Fig. 7.3a.

- Now, adjust the positions of the cups, so that the stick is horizontal.
- Place a burning candle below one of the cups (Fig. 7.3b).
- Observe what happens to the cup.
- Record your observations in Table 7.3 and think of probable reasons.

Fig. 7.3(b): Hot air rising up

Table 7.3: Recording observations and probable reasons

Observation about the cups	Probable reasons for the observation

You observed that the cup under which the candle was placed, rises up (Fig. 7.3b). Why is it so? The air around the candle flame heats up. As the air in the cup warms up, it expands and occupies more space. As a result, it becomes lighter and rises up.

Fig. 7.4: An inflated balloon in the Sun

You can experience the expansion of air on heating it by placing a partially inflated balloon in the Sun (Fig. 7.4). After the air in the balloon gets heated, it expands and the balloon becomes larger.

You must have observed that when an incense stick (*agarbatti*) is burnt, smoke rises up. Smoke is a mixture of hot gases and tiny solid particles that are released when something burns. As it is warmer than the surrounding air, it rises up.

Let us find out how heat transfer takes place in liquids by performing the following activity.

How does heat transfer take place in liquids? Do liquids also rise up when heated like air?

Activity 7.3: Let us find out

Caution—This activity should be carried out under the supervision of a teacher or an adult.

- Take a 500 mL beaker, half-filled with water as shown in Fig. 7.5a.
- With the help of a straw, place a grain of potassium permanganate at the centre of the beaker's base (Fig. 7.5a).
- Place a candle right below the centre of the base of the beaker.

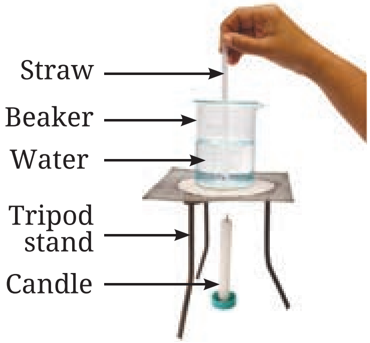


Fig. 7.5(a): Initial set-up for demonstration

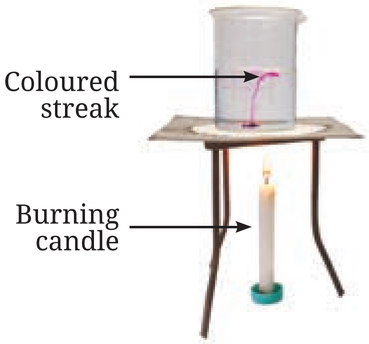


Fig. 7.5(b): Demonstration of convection in heated water

- Observe the movement of the coloured streak in the water.
- As you supply heat, a streak of colour starts moving up and then coming down from the sides (Fig. 7.5b).

Why does the streak of coloured water go up in the middle and come down from the sides? The water at the bottom of the beaker gets heated up and becomes hot. It expands, becomes lighter, and rises. The water on the sides of the beaker is comparatively cooler and heavier, and comes down to take the place of the rising water. Then, this water gets heated and in turn also rises.

This cycle continues until the entire volume of water gets heated. In this case, the entire volume of water gets heated through the actual movement of water particles. This process of heat transfer is known as **convection**. It is because of convection that we see the movement of the coloured streak inside the beaker.

Thus, we can **conclude** that water, like air, gets heated up by the process of convection. Here, heat transfer takes place by the actual movement of particles of liquids and gases from one place to another.

7.2.1 Land and Sea Breeze

Palden shares his experience of visiting a beach in Kerala during winter vacation and says, "During the day, the sand or soil near the beach is hotter than the water in the sea. However, at night, the sand or soil is cooler than the water." Pema replies, "Yes, different objects get heated and cooled differently."

Let us check how land and water get heated and cooled by performing an activity.

Activity 7.4: Let us investigate

Caution—This activity should be carried out on a clear, sunny day under the supervision of a teacher or an adult.

- Take two identical bowls as shown in Fig. 7.6.
- Fill one bowl halfway with soil and the other bowl halfway with water.
- Fix a laboratory thermometer in each bowl as shown in Fig. 7.6. Make sure that the bulbs of the thermometer are immersed in soil and water, and do not touch the bottoms or the sides of the bowls.
- Place the set-up in sunlight.

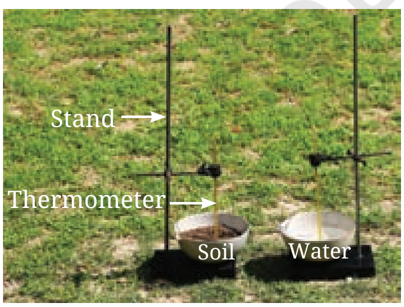


Fig. 7.6: Measurement of the temperature of soil and water

- Measure the temperature of soil and water every 5 minutes and record the data in Table 7.4.

Table 7.4: Temperature of soil and water when heated

S.No.	Time (min)	Temperature of soil (°C)	Temperature of water (°C)
1.	0		
2.	5		
3.	10		
4.	15		
5.	20		

- Study the rise in temperature of soil and water.
- Did the temperature rise by the same amount for both the soil and the water at the same time?
- If not, which one got heated faster?
- How much was the rise in temperature of the soil and the water in 20 minutes?

After 20 minutes, you will find that the temperature of the soil rises more than that of the water. This indicates that the soil heats up faster than water.

Does the soil also cool faster than water? After letting the soil and water get heated, bring the set-up indoors and let it cool for 20 minutes. You will observe that the soil cools faster than water, just as it gets heated faster.

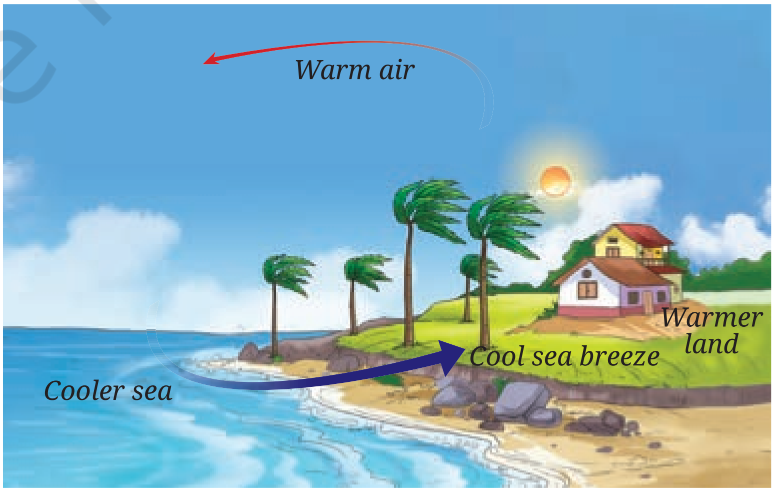


Fig. 7.7(a): Sea breeze

People living in coastal areas experience an interesting phenomenon caused by the heating and cooling of land and water at different rates. As the land gets heated faster than water during the day, it causes warm air above the land to rise. This causes cooler air to move from the sea towards the land. This movement of cooler air from the sea to the land is called **sea breeze** (Fig. 7.7a). Hence, in hot places, sea breeze relieves people from the heat. That is why, windows of the houses in coastal areas are placed facing the sea.

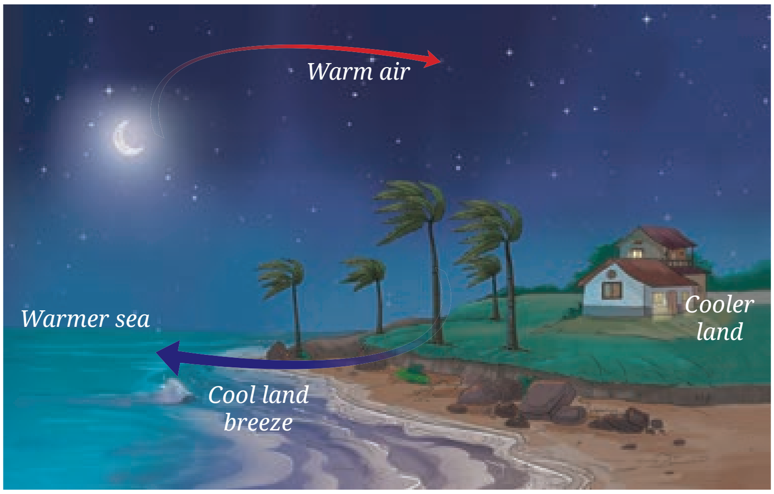


Fig. 7.7(b): Land breeze

At night, the process reverses. In the absence of sunlight, land cools down faster than the water in the sea. As a result, the air above the sea is warmer and rises up. Cooler air from the land then moves towards the sea, creating a **land breeze** (Fig. 7.7b).

Thus, people living near the seashore experience that the direction of the wind reverses in the day and night.

7.3 Radiation

Do you remember when Pema and Palden were sitting around the fireplace? They felt warm.

I wonder how heat from the fire reaches us?

Their grandfather tells them that the heat transfer, in this case, takes place directly from the fire (hot object) to us by a process known as **radiation**. The heat of the Sun reaches us through this process. Heat transfer by radiation does not require any medium.

All objects radiate heat. You must have observed that a hot utensil kept away from the flame cools down after some time. What is the reason for it? The hot utensil cools down by radiating heat to its surroundings.

DIVE DEEPER

Why is it more comfortable to wear white or light-coloured clothes during summers and dark-coloured clothes during winters?

Light-coloured clothes reflect most of the heat that falls on them, and therefore, we feel more comfortable wearing them during summers. Dark surfaces, on the other hand, absorb more heat, and therefore, we feel more comfortable with dark-coloured clothes during winters.

There are many examples in our daily life, where we can observe conduction, convection, and radiation happening together.

Consider the case of water being heated up, as shown in Fig. 7.8. Let us **identify** the various ways in which the pan and the water get heated up, as well as the warmth we feel around the flame and the hot pan. Heat is transferred from the flame to the utensil by conduction. Subsequently, water in the utensil gets heated up by convection. The warmth that we feel around the flame and the hot utensil is due to radiation.

Fig. 7.8: Heating water in a pan

Let us wrap up!

From the activities, examples, and discussions so far, we find that there are three processes by which heat gets transferred. These are conduction, convection, and radiation.

- ❖ In conduction, heating takes place when one particle receives heat, transfers heat to the next particle in contact, and so on. The particles themselves do not move away from their positions.
- ❖ In convection, heat transfer takes place by the actual movement of particles.
- ❖ Note that in conduction and convection, a medium must be present whose particles help in the transfer of heat.
- ❖ In the case of radiation, heat travels from one place to another and no material medium is required for its transfer.

Fascinating Facts

In the upper reaches of the Himalayan region, a traditional room heater locally known as *bukhari* is used to keep rooms warm during winters. It consists of an iron stove in which wood or charcoal is burnt. A long pipe attached to the upper part of the heater serves as a chimney, venting out the smoke. Additionally, the *bukhari* can be used for cooking, as its flat top provides a platform for placing utensils. All the three processes of heat transfer are involved when this device is used for cooking and warming up the room.

Bukhari

You have learnt in the Grade 6 Science textbook *Curiosity*, that the Sun is the main source of heat for the Earth. You have seen your parents drying wet clothes on the clothesline at home. Wet clothes dry faster on a sunny day since the heat from the Sun makes the evaporation of water faster.

Thus, heat from the Sun plays an important role in the evaporation of water, be it from clothes drying on a line or from water bodies like oceans and lakes. Let us look at the phenomenon of water cycle to understand this in more detail.

7.4 Water Cycle

You have also learnt in the Grade 6 Science textbook *Curiosity*, that water exists in three states in nature. As a liquid, it fills the oceans, rivers, and lakes on the Earth. As a solid, it forms snow, ice sheets, and glaciers in the mountains and the polar regions. As a gas, it exists in the form of water vapour in the Earth's atmosphere. During summers, some of the snow and ice gets converted to water due to the Sun's radiation and flows down as rivers, and ultimately into the oceans. The melted ice is replenished by fresh snow during winters.

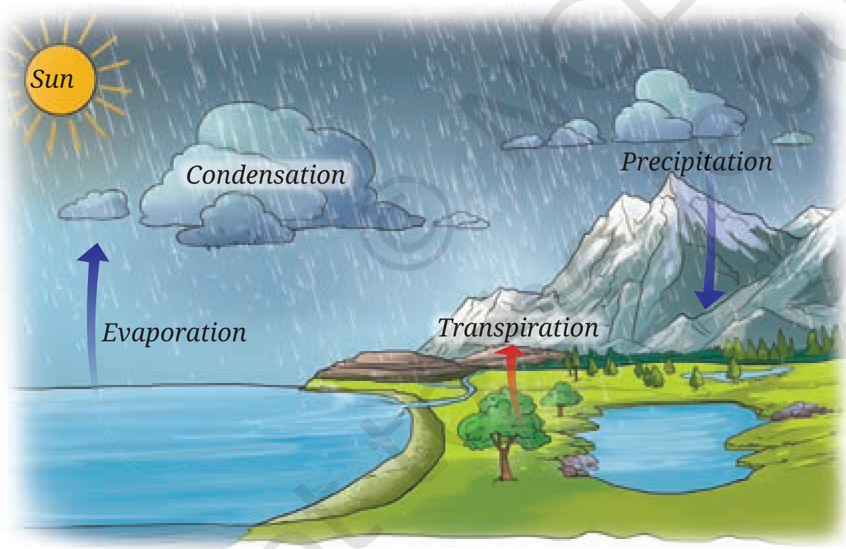


Fig. 7.9: Water cycle

Water in the oceans, rivers, and lakes gets heated due to the Sun, and as a result, it evaporates as water vapour. Water also evaporates from trees and plants through transpiration.

When water vapour rises up, it cools down and condenses to form clouds. Clouds bring rain, snow, and hail. This process is called **precipitation**.

The continuous movement of water—upward as water vapour and downward through precipitation, passing through soil, rocks, and plants, and finally returning to water bodies, is called **water cycle** (Fig. 7.9). Thus, the water cycle helps in redistributing and replenishing water in rivers, lakes, and oceans. It also serves to conserve the total amount of water on the Earth. Rainwater that falls on the surface of the Earth, flows into ponds, lakes, rivers, and oceans or seeps into the ground.

Know a Scientist

Varahamihira was an astronomer and mathematician of the sixth century CE in Ujjaini (modern-day Ujjain), Madhya Pradesh. In his work *Brihatsamhita*, he gave methods for predicting seasonal rainfall. His predictions of seasonal rainfalls were based on factors, such as cloud formation, wind patterns, position of stars and the moon, and other natural phenomena.

You may have seen people drawing water from wells or handpumps. This is the water that has seeped into the ground.

Let us understand how water seeps through the surface of the earth by performing an activity.

How does water seep through the surface of the Earth?

7.4.1 Seepage of water beneath the Earth

Activity 7.5: Let us investigate

- Take three transparent, used plastic bottles of 1 L capacity.
- Cut them in the middle and make a small hole in the cap of each bottle.
- Keep them inverted and put some clay in one bottle, sand in the second, and gravel in the third, as shown in Fig. 7.10.

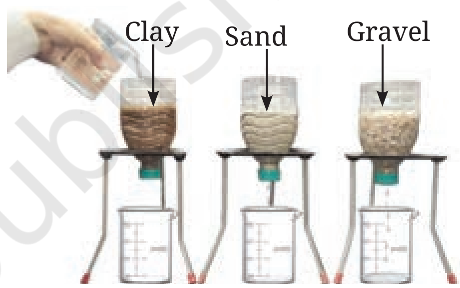


Fig. 7.10: An activity to compare the flow of water through clay, sand and gravel

- Place three identical beakers below each bottle.
- Add 200 mL of water to each bottle.
- Predict the amount of water flowing out of each bottle.
- Collect the water that flows through each bottle for 10 minutes.
- Compare the amount of water that comes through each bottle.

Table 7.5: Seepage of water

Bottles filled with	Prediction	Observation
	Seepage of water (very slow/slow/fast)	Seepage of water (very slow/slow/fast)
Bottle 1 (Clay)		
Bottle 2 (Sand)		
Bottle 3 (Gravel)		

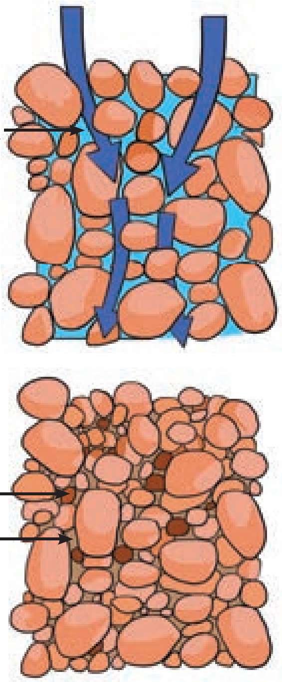


Fig. 7.11: Water readily moves, and is stored where spaces are wide, open and connected

Do your findings match with your predictions?

You may have observed that water seeps fastest through gravel, slower through sand, and slowest through clay. Why is it so? The spaces between gravel particles are wider when compared to those in sand and clay. Hence, water can seep through the gravel more easily. In this way, water seeps beneath the surface of the Earth. This process of surface water seeping through soil and rocks is called **infiltration**. Water can infiltrate more readily if the spaces between soil and rock particles are wider, open, and interconnected (Fig. 7.11).

The water that seeps through gets stored in the pore spaces of sediments and the openings in rocks beneath the surface as **groundwater**. The underground layers of sediments and rocks that store water in pore spaces are called **aquifers** (Fig. 7.12). This is the water we extract by digging wells or drilling bore wells into aquifers. This water may be a few metres to hundreds of metres below the ground, depending on the location.

Fig. 7.12: Aquifer

However, groundwater is not unlimited. The growing water requirements of an increasing population have led to excessive groundwater extraction. Additionally, decreased vegetation cover and increased concrete surfaces in urban areas have limited water infiltration. As a result, groundwater is getting depleted. To address this, rainwater harvesting and recharge pits are used to replenish groundwater. Hence, the water cycle ensures that groundwater sources are recharged, thereby helping to ensure a sustainable groundwater supply.

Since water scarcity makes life difficult, people have developed different ways to conserve water. For example, in Ladakh, people have developed innovative ways to conserve water by making ice stupas (Fig. 7.13) during the winters.

Science and Society

Ice Stupa

During the spring season in Ladakh, streams often dry up, leading to scarcity of water as the heat from the Sun's radiation is not enough to melt the snow on the mountains. During winters, water from mountain streams is channeled down through underground pipes. This water is then sprayed into the cold air. As it falls, it freezes due to extremely low temperatures.

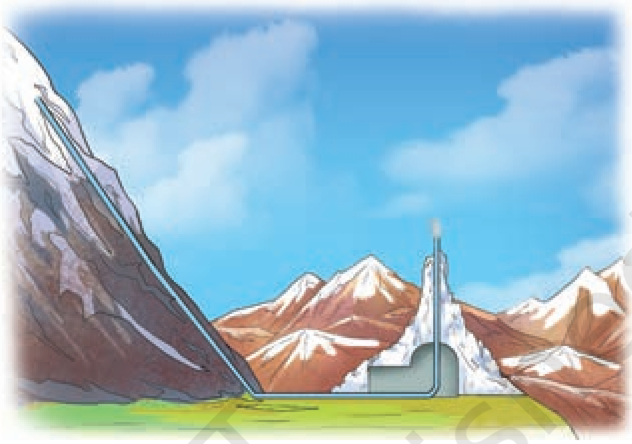


Fig. 7.13: Ice stupa

The ice builds up layer by layer, creating a tall, cone-shaped structure called an **ice stupa** as shown in Fig. 7.13. The ice stupa melts slowly during spring, providing water for farming and other needs throughout the summer.

In a Nutshell

- There are three ways in which heat is transferred from one place to another—conduction, convection, and radiation.
- The process of heat transfer from the hotter part of an object to a colder part is called conduction. In this process, particles do not move from their positions.
- Materials that allow heat to pass through them easily are called good conductors of heat.
- Materials that do not allow heat to pass through them easily are called poor conductors (insulators) of heat.
- In solids, heat is mainly transferred through the process of conduction. In liquids and gases, heat is transferred by the process of convection.

- ❖ In convection, heat transfer takes place by the actual movement of particles. Land and sea breezes are examples of the process of convection.
- ❖ Heat from the Sun reaches the Earth through radiation.
- ❖ All objects exchange heat with their surroundings through the process of radiation.
- ❖ Processes of conduction and convection require a medium for heat transfer but no medium is required for the radiation process.
- ❖ The principles of heat transfer are utilised in designing houses and clothing.
- ❖ The continuous movement of water—upward as water vapour and downward through precipitation, passing through soil, rocks and plants, and finally returning to water bodies, is called water cycle.
- ❖ The process of surface water seeping through soil and rocks is called infiltration.
- ❖ Groundwater is the water that seeps through and gets stored in the pore spaces of sediments and the openings in rocks beneath the surface.
- ❖ The underground layers of sediments and rocks that store water in pore spaces are called aquifers.

Let Us Enhance Our Learning

1. Choose the correct option in each case.

   (i) Your father bought a saucepan made of two different materials, A and B, as shown in Fig. 7.14. The materials A and B have the following properties—

   (a) Both A and B are good conductors of heat
   (b) Both A and B are poor conductors of heat
   (c) A is a good conductor and B is a poor conductor of heat
   (d) A is a poor conductor and B is a good conductor of heat

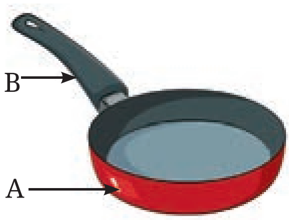


Fig. 7.14: Saucepan

   (ii) Pins are stuck to a metal strip with wax and a burning candle is kept below the rod, as shown in Fig. 7.15. Which of the following will happen?

   (a) All the pins will fall almost at the same time
   (b) Pins I and II will fall earlier than pins III and IV
   (c) Pins I and II will fall later than pins III and IV
   (d) Pins II and III will fall almost at the same time

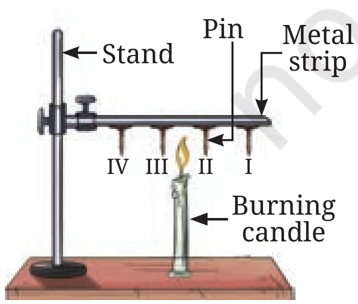


Fig. 7.15: Heat transfer set-up

(iii) A smoke detector is a device that detects smoke and sounds an alarm. Suppose you are fitting a smoke detector in your room. The most suitable place for this device will be:

(a) Near the floor

(b) In the middle of a wall

(c) On the ceiling

(d) Anywhere in the room

2. A shopkeeper serves you cold *lassi* in a tumbler. By chance, the tumbler had a small leak. You were given another tumbler by the shopkeeper to put the leaky tumbler in it. Will this arrangement help to keep the *lassi* cold for a longer time? Explain.

3. State with reason(s) whether the following statements are True [T] or False [F].

(i) Heat transfer takes place in solids through convection. [ ]

(ii) Heat transfer through convection takes place by the actual movement of particles. [ ]

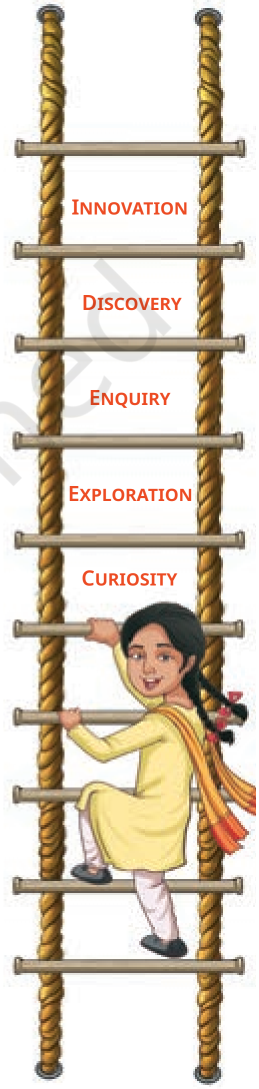
(iii) Areas with clay materials allow more seepage of water than those with sandy materials. [ ]

(iv) The movement of cooler air from land to sea is called land breeze. [ ]

4. Some ice cubes placed in a dish melt into water after sometime. Where do the ice cubes get heat for this transformation?

5. A burning incense stick is fixed, pointing downwards. In which direction would the smoke from the incense stick move? Show the movement of smoke with a diagram.

6. Two test tubes with water are heated by a candle flame as shown in Fig. 7.16. Which thermometers (Fig. 7.16a or Fig. 7.16b) will record a higher temperature? Explain.



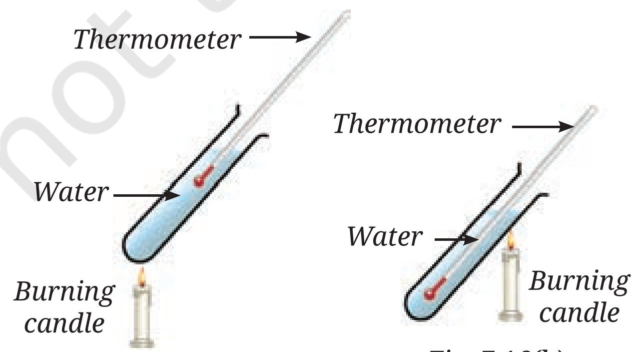
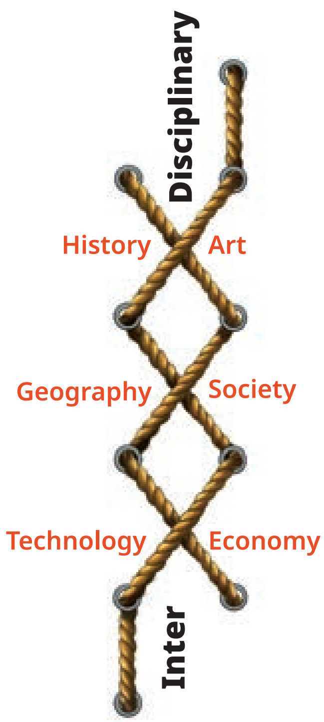


Fig. 7.16(a) *Fig. 7.16(b)*

Fig. 7.16: Two thermometers dipped in two test tubes

7. Why are hollow bricks used to construct the outer walls of houses in hot regions?
8. Explain how large water bodies prevent extreme temperature in areas around them.
9. Explain how water seeps through the surface of the Earth and gets stored as groundwater.
10. The water cycle helps in the redistribution and replenishment of water on the Earth. Justify the statement.

Exploratory Projects



❖ Society: Visit a site of water harvesting or a recharge pit. Find out from people how they are constructed and how they work. Prepare a report with illustrations.

❖ Activity: Tightly wrap a thin paper strip around a metallic rod. Try to burn the paper with a candle while rotating the rod continuously. Does the paper burn? Explain your observations.

❖ Activity: Take a sheet of paper. Draw a spiral on it, as shown in Fig. 7.17a. Cut the paper along the spiral. Suspend the paper as shown in the Fig. 7.17b above a burning candle. Observe what happens. Provide an explanation for your observation.

Fig. 7.17(a): Cutting paper in spiral

Fig. 7.17(b): Spiral paper above a burning candle