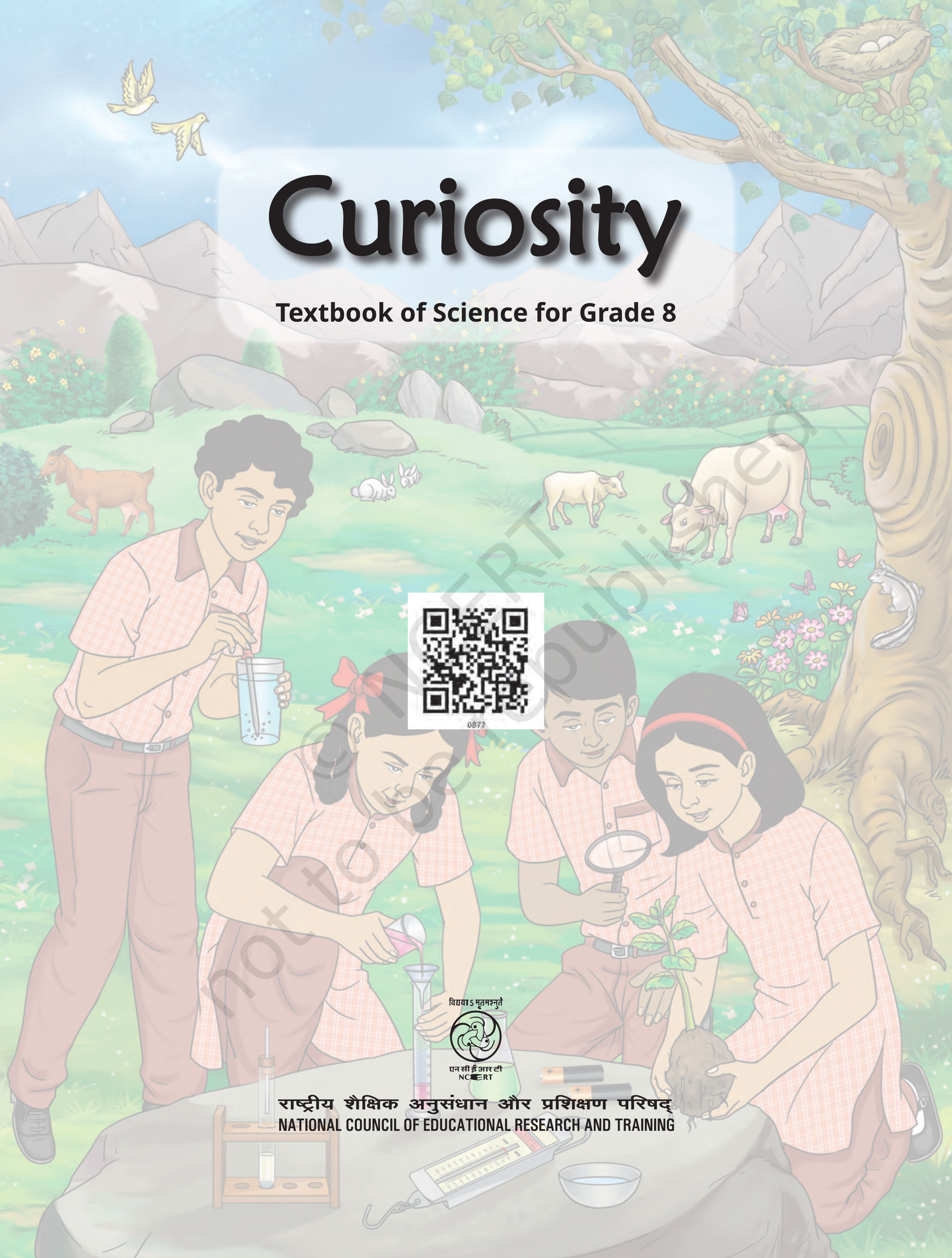
# Curiosity

**Textbook of Science for Grade 8**



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एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

**0877 – CURIOSITY**
Textbook of Science for Grade 8

ISBN 978-93-5729-772-1

***First Edition***
*June 2025 Jyeshtha 1947*

**PD 1500T SM**



**₹ 65.00**

*Printed on 80 GSM paper with NCERT watermark*

Published at the Publication Division by the Secretary, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016 and printed at Laxmi Offset Printers, G–114-115, Heerawala Industrial Area, Kanota, Agra Road, Jaipur.



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# Foreword

The National Education Policy (NEP) 2020 envisages a system of education in the country that is rooted in an Indian ethos and its civilisational accomplishments in all fields of knowledge and human endeavour. At the same time, it aims to prepare students to engage constructively with the opportunities and challenges of the twenty-first century. The basis for this aspirational vision has been well laid out by the National Curriculum Framework for School Education (NCF-SE) 2023 across curricular areas at all stages. By nurturing students' inherent abilities across all five planes of human existence (*pañchakośhas*), the Foundational and Preparatory Stages set the Stage for further learning at the Middle Stage. Spanning Grades 6 to 8, the Middle Stage serves as a critical three-year bridge between the Preparatory and Secondary Stages.

The NCF-SE 2023, at the Middle Stage, aims to equip students with the skills that are needed to grow, as they advance in their lives. It strives to enhance their analytical, descriptive, and narrative capabilities, and to prepare them for the challenges and opportunities that await them. A diverse curriculum, covering nine subjects ranging from three languages—including at least two languages native to India—to Science, Mathematics, Social Sciences, Art Education, Physical Education and Well-being, and Vocational Education promotes their holistic development.

Such a transformative learning culture requires certain essential conditions. One of them is to have appropriate textbooks in different curricular areas, as these textbooks are intended to play a central role in mediating between content and pedagogy—a role that helps strike a judicious balance between direct instruction and opportunities for exploration and inquiry. Among other conditions, classroom arrangement and teacher preparation are crucial to establish conceptual connections both within and across curricular areas.

The National Council of Educational Research and Training, on its part, is committed to providing students with such high-quality textbooks. Various Curricular Area Groups, which have been constituted for this purpose, comprising notable subject-experts, pedagogues, and practising teachers as their members, have made all possible efforts to develop such textbooks. The *Curiosity*, textbook of science for Grade 8 is designed to make learning fun, engaging, and meaningful. Aligned with the NEP 2020 and the NCF-SE 2023, the textbook promotes experiential and inquiry-based learning. It encourages students to ask questions, think critically, and understand scientific concepts through real-world contexts. Integrating physics, chemistry, biology, and earth science, the textbook also highlights environmental awareness, ethical values, and insights from India's rich tradition of knowledge. Featuring numerous hands-on activities and relatable examples, the book aims to simplify complex topics and foster deeper understanding. Collaborative learning is encouraged through group work and peer discussions, helping learners develop creativity, logical thinking, and decision-making skills. Rather than simply reading about science, students are guided to explore, question, and experience it actively—making the learning process both enjoyable and impactful.

However, in addition to this textbook, students at this stage should also be encouraged to explore various other learning resources. School libraries play a crucial role in making such resources available. Besides, the role of parents and teachers will also be invaluable in guiding and encouraging students to do so.

With this, I express my gratitude to all those who have been involved in the development of this textbook, and hope that it will meet the expectations of all stakeholders. At the same time, I also invite suggestions and feedback from all its users for further improvement in the coming years.

Dinesh Prasad Saklani
*Director*
National Council of Educational
Research and Training

New Delhi
*June 2025*

# About this Book

After exploring the *Curiosity*, Grade 7 textbook, we hope you discovered new ideas and found yourself wondering even more about the world around you! Our journey of exploration continues in *Curiosity* for Grade 8, where you will learn to ask deeper questions, design investigations, and think like real scientists.

The Grade 8 textbook of science has been developed in alignment with the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE) 2023. It is expected that all competencies outlined for the final year of Middle Stage (Grade 8) are achieved. This textbook is designed to help you learn about important topics, such as matter, the physical and living world, health, hygiene, and the connection between science, technology, and society. It also helps you understand how science works and how scientists think and explore. The main aim of *Curiosity* is to help you become a responsible and thoughtful member of society.

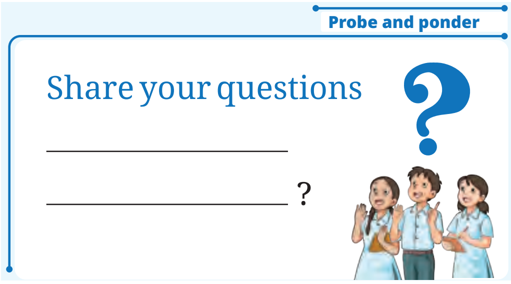
The textbook integrates topics from biology, chemistry, physics, and earth science. It also incorporates essential themes, such as environmental care, value education, inclusivity, health, hygiene, and India's traditional knowledge systems. The goal is to help you learn through real experiences rather than by simply memorising facts.

*Curiosity*, the textbook of science for Grade 8, contains 13 chapters. Each chapter includes engaging activities, thought-provoking questions, and clear illustrations to support your learning. The first chapter is titled **Exploring the Investigative World of Science**. It gives you a quick look at the various topics you will come across in this book and is designed to get you more excited about science! This chapter takes you to the next step—entering the investigative world of science, where curiosity, wonder, and discovery come together. You will learn to ask focused questions, design and try out simple experiments to help answer them, and use your observation, exploration, and investigation skills to understand how things work. This chapter is meant to be a fun and friendly introduction to your science journey.

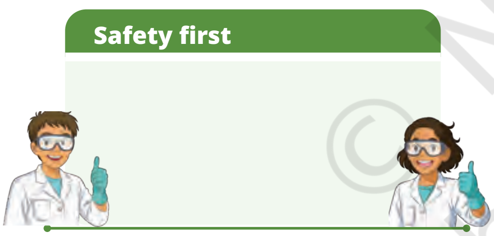
Probe and ponder

Dear Young Scientists,

Each chapter begins with a picture linked to the chapter that is designed to spark curiosity, capture your attention, and connect prior knowledge to new concepts. There are a few **Probe and ponder** questions. These are critical thinking questions that are not for evaluation and do not always have simple answers. Instead, they make you think more deeply and explore new ideas. Some of these questions are open-ended and thought-provoking because they do not just ask for a fact or a quick answer. Instead, they ask *why* or *how*, encouraging you to think critically and stay curious. You may not always be able to find the answers to these questions even after going through the chapter, but do not worry. They will help you link different concepts and deepen your curiosity, and perhaps help you understand the process of science. Many of these questions will also be explored further in higher grades. In fact, we are sure you may also have such questions, and there is space to add your own!

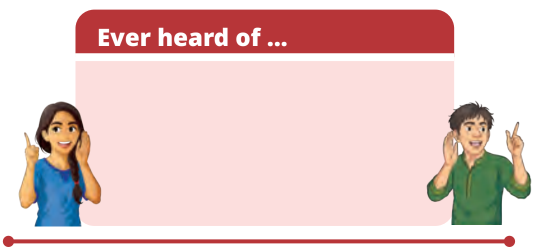


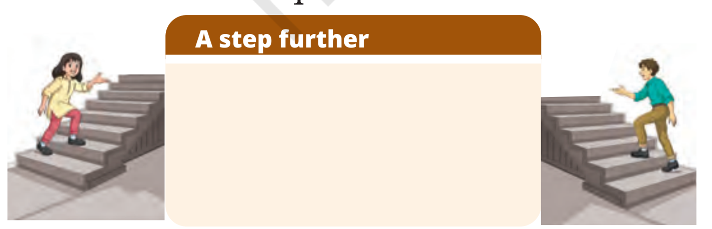

The activities in the book are designed to reflect how science works, offering both hands-on and minds-on experiences. These activities promote teamwork and are inclusive in nature, ensuring participation from all students. Teachers are expected to pay extra attention while supporting children with special needs, especially during experiments involving light, heating devices, microscopes, etc. Teachers should assist these students in visualising the experimental setup. Additionally, they may encourage peer interactions to help students understand concepts of science better. The text also includes questions to help students assess their understanding and reflect how much they have learnt. Many of these questions are aimed at encouraging students to think deeply, reflect on their own ideas, and analyse concepts critically.




In some activities **Safety first**, has been given to keep students safe, especially when using hot, sharp, or breakable materials. These precautions help prevent accidents and make sure everyone can enjoy the activity while learning safely.

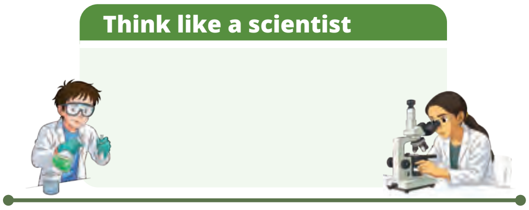
To sustain the students' interest, some challenging ideas, additional information, interesting facts, and other engaging materials are presented in boxes labelled **Ever heard of ...**, which highlight fascinating facts, interesting observations, and curiosity-driven questions.




**A step further** boxes contain advanced concepts that explore the topic in more depth. The information given in these boxes also brings scientific principles and knowledge into real-life applications, showing how science has contributed to societal development.

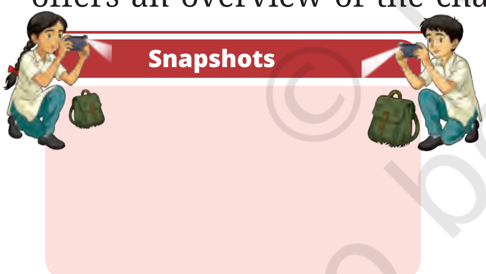

**Our scientific heritage** offers information about institutions which have contributed to the progress of scientific temper and any personality or their works of 'heritage level repute'.



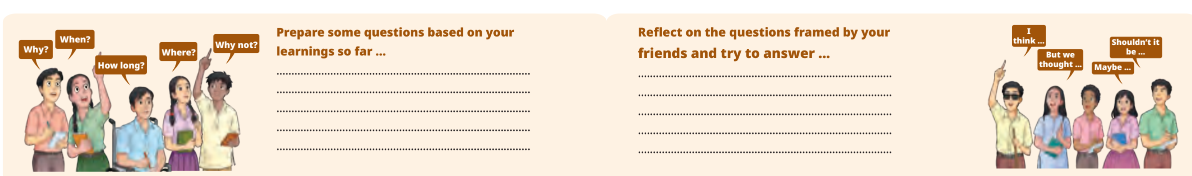

You will find a **Think like a scientist** section in some chapters, where you can explore the experiment further by making modifications or trying different approaches. It will help you to investigate more deeply and allow new questions to emerge in your minds.


Some chapters also feature a section called **Be a scientist**, where you can learn about the contributions of Indian and international scientists related to the topic. These sections include brief biographies and show how scientists have made a difference. Additionally, an interesting element that has been incorporated in some of the chapters is the introduction of certain verses from various Indian texts to promote rootedness in the learners as envisaged in NEP 2020.

The **Snapshots** section provides the summary of a chapter, which offers an overview of the chapter's main points, reinforcing the key ideas discussed. Each chapter includes **Keywords** in between the text that highlight key concepts and steps in science, helping learners understand ideas and think critically. These keywords also outline the procedures in scientific activities.




**Keep the curiosity alive** includes a range of exercises, from pictorial questions and puzzles to multiple choice questions, offering a challenging and engaging experience. These questions also help assess the competencies developed by learners in each chapter. We recommend teachers to use questions similar to those found in this section for evaluation.

A key feature of the book is **Discover, design, and debate**, which includes activities/projects designed to encourage interaction with experts, teachers, parents, and the community. Students are encouraged to gather diverse information and draw their own conclusions. These support the development of thoughtful, active, and compassionate learners. It makes science more fun, meaningful, and connected to life—as it no longer remains about reading and memorising, but also about doing. Some projects may require prior preparation.


Friends! Science is full of wonders, and there is always more to discover. That is why the Grade 8 textbook also ends with a page called **It's never the end, my friend!**

The textbook is one way to learn, but learners should also explore and observe their surroundings. Information and Communication Technology (ICT) can further enhance learning when used appropriately. QR codes in the textbook provide access to interactive resources like videos, puzzles, games, quizzes, audio, and additional content, allowing learners to explore at their own pace.

Now, with *Curiosity* in your hands, keep exploring, keep questioning, and never stop being curious.

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# THE CONSTITUTION OF INDIA

## PREAMBLE

**WE, THE PEOPLE OF INDIA,** having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

**JUSTICE,** social, economic and political;

**LIBERTY** of thought, expression, belief, faith and worship;

**EQUALITY** of status and of opportunity; and to promote among them all

**FRATERNITY** assuring the dignity of the individual and the [2][unity and integrity of the Nation];

**IN OUR CONSTITUENT ASSEMBLY** this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

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# Acknowledgements

The National Council of Educational Research and Training (NCERT) acknowledges the guidance and support of the esteemed Chairperson and members of the National Curriculum Framework Oversight Committee for their invaluable contributions in overseeing the translation of NCF-SE 2023 perspectives into the textbook. NCERT is also deeply grateful to the Chairperson, Co-Chairperson, and members of the National Syllabus and Teaching Learning Material Committee for their continuous guidance and thorough review of the textbook. Furthermore, NCERT extends its heartfelt thanks to the Chairperson and members of the Sub-Group: Science, as well as other relevant CAGs, for their support and guidelines on the cross-cutting themes.

The Council gratefully acknowledges Sridhar Srivastava, Former *Joint Director*, NCERT; P.C. Agarwal, *Joint Director*, NCERT; Aman Sharma, *Secretary*, NCERT and *Joint Director*, CIET, NCERT; Amarendra P. Behera, *Professor* and *Head*, PRD, CIET, NCERT; Ranjana Arora, *Professor* and *Head*, DCS&D, NCERT; Sunita Farkya, *Professor* and *Head*, DESM, NCERT; and Ashutosh Kedarnath Wazalwar, *Professor* and *Head*, PMD, NCERT, New Delhi, for their academic, administrative, and technical support.

Special thanks are due to Aniket Sule, *Associate Professor*, HBCSE, TIFR, Mumbai, for his valuable inputs on tribal astronomy; Ruchi Shukla, *Assistant Professor*, Department of Educational Psychology and Foundations of Education, NCERT, New Delhi, for her contribution to Chapter 3; Linto Alappat, *Assistant Professor*, Christ College Autonomous, Irinjalakuda, Thrissur, Kerala, who provided six photographs featured in Chapter 8; Amogh Sahaje, *Researcher*, 100 Suns, whose photograph appears in Chapter 10; and the Indian Space Research Organisation (ISRO), which supplied photographs included in Chapters 11 and 13. The Council also thanks Mohamed Hakif P. and Sai Shetye, HBCSE, TIFR, Mumbai, for preparing some illustrations used in Chapter 11, and Sachin Kishore, *Deputy Director General* (Philately), Postal Directorate, Dak Bhawan, New Delhi, for granting access to high-resolution images of Indian postal stamps related to migratory birds of India.

NCERT appreciates the contributions of Suparna Diwakar, *Educator* and *Chief Consultant*, Programme Office, NSTC; M. Pramod Kumar, *Senior Consultant*; Vaishali Sukhija, *Consultant*; Yadunath Deshpande, *Member*; and other members of the Programme Office, NSTC, NCERT, New Delhi, for their valuable inputs.

The Council acknowledges the dedicated efforts of Archana, Dharmendra Kumar, Monika Lamoria, and Preeti Sharma, *Senior Research Associates*; Nitika Rani, *Course Administrator*; Amar Kumar, Neha, and Gaurav Sonare, *Junior Project Fellows*; and Brijesh, Himani, and Nitin, *Graphic Designers*, DESM, NCERT, New Delhi.

Gratitude is also extended to Ankeeta Bezboruah, *Freelance Language Editor*, for her meticulous editing of the textbook manuscript. The Council sincerely appreciates the support provided by the APC office and the administrative staff of DESM.

Finally, the Council gratefully acknowledges Garima Syal, *Assistant Editor*, for her valuable contribution in shaping this book. Thanks are also extended to Pawan Kumar Barriar, *In-charge*, DTP Cell, Publication Division, NCERT; Sachin Tanwar, Sadiq Saeed, and Manoj Kumar, *DTP Operators* (Contractual); and Rajat Subhra Roy, Keshav Kumar, and Jatinder Kumar, *Proofreaders* (Contractual), Publication Division, NCERT, New Delhi, for their meticulous efforts and unwavering commitment throughout the publication process.

# Constitution of India

**Part IV A (Article 51 A)**

# Fundamental Duties

It shall be the duty of every citizen of India —

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, and wildlife, and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;

*(k) who is a parent or guardian, to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

**Note:** The Article 51A containing Fundamental Duties was inserted by the Constitution (42nd Amendment) Act, 1976 S.11 (with effect from 3 January 1977).

*(k) was inserted by the Constitution (86th Amendment) Act, 2002 S.4 (with effect from 1 April 2010).

# Contents

# CONSTITUTION OF INDIA

**Part III (Articles 12 – 35)**
(Subject to certain conditions, some exceptions and reasonable restrictions)

guarantees these

# Fundamental Rights

**Right to Equality**

- before law and equal protection of laws;
- irrespective of religion, race, caste, sex or place of birth;
- of opportunity in public employment;
- by abolition of untouchability and titles.

**Right to Freedom**

- of expression, assembly, association, movement, residence and profession;
- of certain protections in respect of conviction for offences;
- of protection of life and personal liberty;
- of free and compulsory education for children between the age of six and fourteen years;
- of protection against arrest and detention in certain cases.

**Right against Exploitation**

- for prohibition of traffic in human beings and forced labour;
- for prohibition of employment of children in hazardous jobs.

**Right to Freedom of Religion**

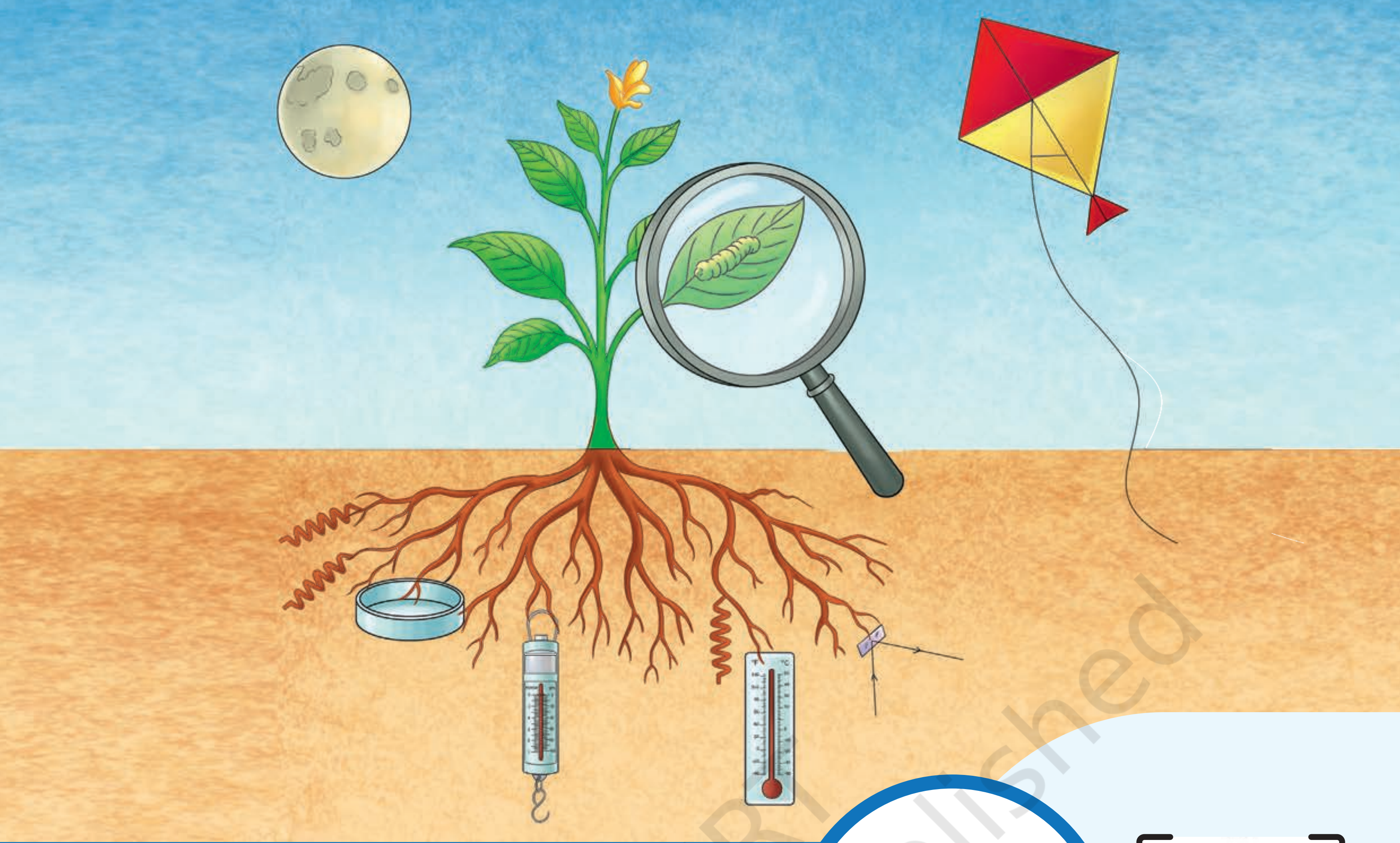
- freedom of conscience and free profession, practice and propagation of religion;
- freedom to manage religious affairs;
- freedom as to payment of taxes for promotion of any particular religion;
- freedom as to attendance at religious instruction or religious worship in certain educational institutions.

**Cultural and Educational Rights**

- for protection of interests of minorities;
- for minorities to establish and administer educational institutions;
- saving of certain Laws 31A–31D.

**Right to Constitutional Remedies**

- by issuance of directions or orders or writs by the Supreme Court and High Courts for enforcement of these Fundamental Rights.



# Exploring the Investigative World of Science

# 1

## Probe and ponder

Dear Young Scientists,

Welcome back! On the first page of each chapter, you will find a set of questions. These are not meant for any exam—they are unique invitations to spark your curiosity to explore the world of science!

Why is one side of a *puri* thinner than the other?

Are there more grains of sand on all the beaches and deserts of the world, or more stars in our galaxy?

Right from Grade 6, we've observed the incredible diversity of plants and animals around us. From the different shapes of leaves to the many kinds of insects—why has nature created such a vast variety?

Is there such a question that makes you curious about the world?

Write it here! ________________________________

Our journey with *Curiosity*, into the world of science continues in Grade 8. We hope you bring along the spirit of adventure and exploration that has guided us so far. In Grade 6, we discovered how science begins with wonder, with simple "Why?" and "How?" questions about the world around us.

In Grade 7, we learnt that science is always evolving—that each answer opens new questions, and how our ideas can slowly change as we explore deeper. Now, in Grade 8, we take the next step: entering the Investigative World of Science, where wonder and evolution come together to form the heart of how science works.

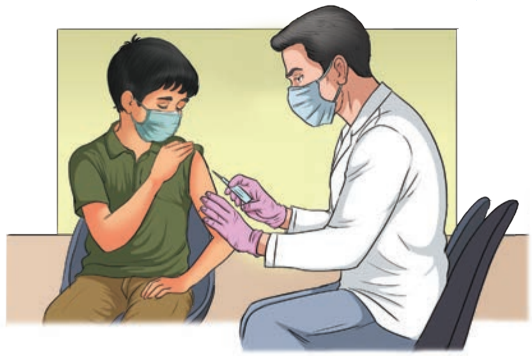
We don't want you to just learn new facts, we want you to learn how to find new facts. Investigation in science means more than just looking at something and asking only simple questions. Now you can ask more focused questions, and design ways to perhaps do simple experiments to answer those questions, and then use your observations to improve your understanding.

Step by step, we will learn how to use questions as starting points to try to observe carefully, experiment thoughtfully, and explain clearly what we see. In doing so, each of you won't just be learners but also investigators, young scientists, exploring real-world puzzles. These may range from everyday life—like why does dough rise?—to the bigger mysteries of Earth and beyond like is the world getting warmer?

As you turn each page of this book, we hope you notice the interesting design of our page numbers once again. On the left-hand pages, at the bottom, you'll find the image of a root, symbolising the deep, solid foundation of knowledge that keeps us connected to our environment, traditions, and our cultural and natural heritage.

On the right-hand pages, in the top corner, you'll find a kite soaring in the sky, reminding us that curiosity must take flight if we are to explore the unknown. Together, these two symbols—the root and the kite—invite you to stay grounded in real observations, while allowing your ideas to soar towards new horizons. Remember, investigation in science works best only when we balance the solid ground of careful observation with the freedom of creative thinking.

You will also notice some patterns in the lines at the bottom of the page. There are some hidden scientific thoughts in these as well. But don't worry, they are mainly to make the page a little less boring. Let us now take a brief look at the various stops on our journey this year, and see where our curiosity, supported by strong roots and lifted by soaring ideas, might take us!



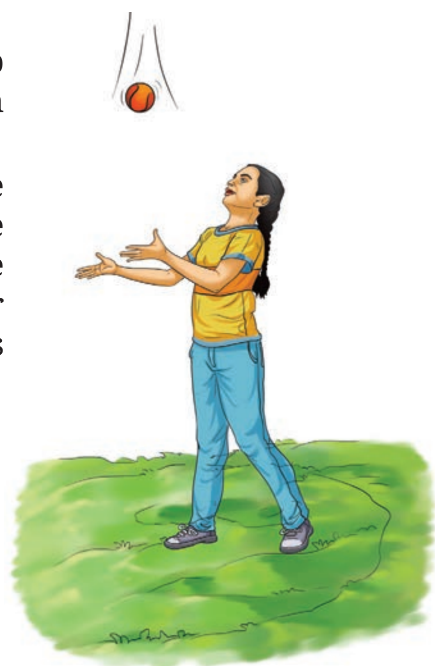
This year, our investigative adventure will take us on a journey from the tiny microbes we can't see to planet-wide challenges we can't ignore.

We will start by examining something as small as a single drop of water, and uncover a hidden world of tiny organisms, unseen but deeply linked to us. Some of these are invisible helpers, that help us digest our food or produce medicines, while others can be harmful, causing infections.

But what does our body need to stay healthy? How do we fight these infections? We'll find out how nutritious food, exercise, medicines, and vaccines help us stay healthy and fight infections. But that's just the beginning. In today's world, science does play a major role in improving our lives.

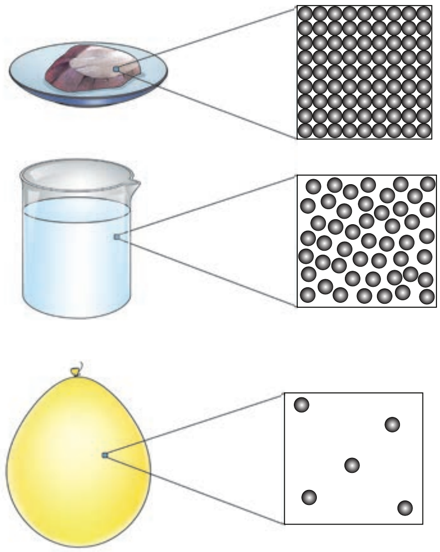
For example, we use electric current in many ways to help make our lives easier. We depend on the heating effect of electric current to keep us warm, while the magnetic effect helps motors run and machines function.

These phenomena depend on fundamental forces. So after watching electricity do work, we move on to study these forces themselves, starting with those that make objects speed up, slow down, or change direction.



Understanding forces helps explain why a ball thrown up in the air falls back to the ground, or why a car stops when the brakes are applied.

This also leads us to the idea of pressure—how the force is distributed over an object. The same concepts of force and pressure also decide how air moves. A small difference in pressure can result in a gentle breeze while a stronger pressure difference can lead to strong winds, and sometimes even cyclones.



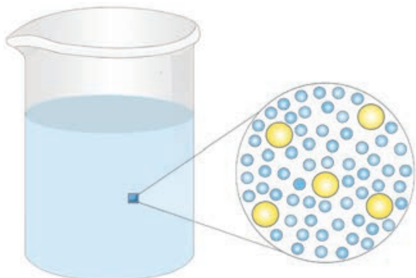
So, these forces are connected to powerful weather events—like storms and cyclones—that affect our daily lives, agriculture, and even our safety.

To truly understand how air can exert pressure or why water boils at a certain temperature we need to zoom into these materials and see what kind of particles they are made up of, and how they move around.

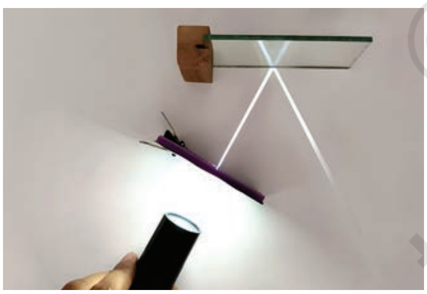
Everything around us is made of tiny particles. In materials that are solid these particles cannot move much, while in gases they can move around freely.

Classifying things around us is an important feature of science. We can also classify materials around us into elements (pure substances), compounds (two or more elements bonded together), and mixtures (combinations that can be separated physically).

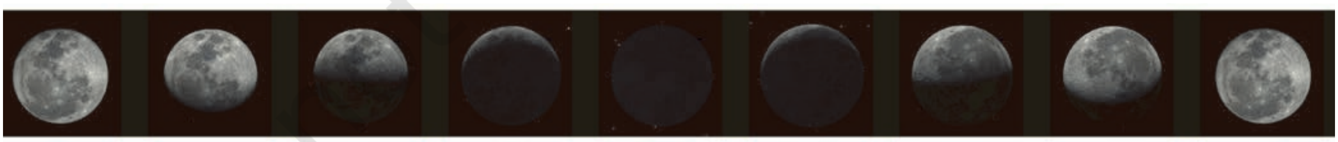
Once we know how particles combine or mix, we can then understand solutions—for example, how sugar dissolves in tea to make it sweet.



From the world of particles and mixtures, we then move into the world of light. We'll study how light rays reflect off flat and curved mirrors, and bends when passing through lenses and helps us understand the working of many objects around us. The bending of light explains what happens when we see an image in a shiny metal spoon or how corrective glasses help many of us see clearly.



It's not just a polished mirror that reflects light, rough surfaces reflect light as well, and so does the Moon. Depending on the relative positions of the Earth, Moon and Sun, a slightly different part of the Moon is illuminated each night, giving rise to the beautiful phases of the Moon that we see in the sky.



Watching the periodic cycles of the Moon's phases allowed humans to come up with the first calendars. By combining careful observations of sunrises, sunsets, and lunar cycles, various calendars came into being. Isn't it fascinating that the calendars which determine our routines on Earth are linked to the motions of objects far beyond our planet?

But it's not just calendars or the movements of the Sun and Moon that are linked. Right here on Earth, there are marvellous and complex patterns of relationships between living organisms and their environments. Every living being—from tiniest insect to the largest whale, from blades of grasses to tall trees—depends on and responds to the air, water, sunlight, and other organisms around them forming the ecosystems that support life on our planet.

**Chaitra**
(March 22 - April 20, 2025)

| SUN<br>रवि | MON<br>सोम | TUE<br>मंगल | WED<br>बुध | THU<br>गुरू | FRI<br>शुक्र | SAT<br>शनि |
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| 23 13 | 24 15 | 25 14 | 26 16 | 27 17 | 28 18 | 29 19 |
| 30 20 | | | | | | |

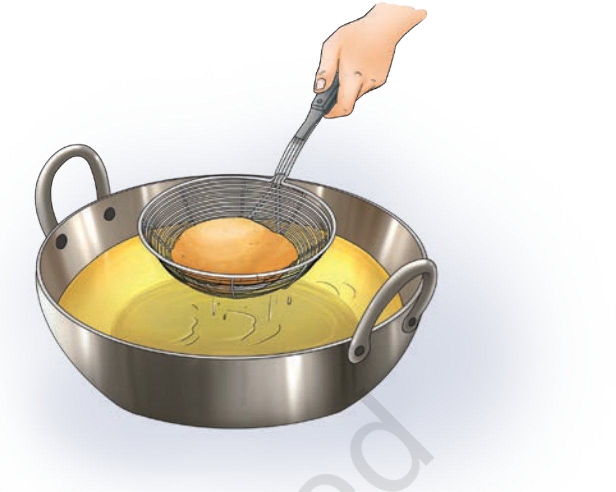
In the final chapter of this book, we can put it all together and try to understand what makes Earth 'just right' for life and to recognise the urgent challenges that our planet now faces.

Most importantly, the Earth lies at the perfect distance from the Sun, where water remains liquid, and it has an atmosphere that provides the oxygen we breathe while shielding us from harmful ultraviolet rays. But human activities on the planet can cause small changes in the temperature of the Earth, disrupting climate patterns, with dangerous consequences.

At the heart of both the problem—and any possible solution—is us. We are the ones influencing Earth's climate. But we are also the ones who can—and must—use science to understand these changes and guide our actions.

The same scientific principles that we have guided our journey through the middle stages—observing, measuring, experimenting—will be key in helping us protect the delicate balance on which life depends. The challenges ahead won't always be easy. We hope some of you will try to solve these difficult problems with *Curiosity* as your guide.

**To help you think like a scientist, let us go back to a question we asked on the first page: Why is one side of a *puri* thinner than the other?**



Firstly, remember that science is everywhere! You don't need a fancy laboratory to do simple experiments. Even your kitchen at home is a wonderful place to observe and ask questions. All you need is to start with curiosity, careful observation, and asking what happens if…? Have you noticed how a *puri* or a *batura* puffs up when placed in hot oil? Or how a *phulka* swells when put directly on the flame. Why does it puff up like a balloon? And why is one side thinner than the other? These are questions a scientist might ask—and you can too! Let's see how we can investigate this simple everyday phenomenon like a scientist would.

First, we will try to ask a scientific question. What are the different things that may change the way a *puri* puffs up when fried? To answer this, we may want to do some simple experiments. For that, we try and find out two main things—what all can we change or control when we do the experiment, and what all can we observe to see if these changes made any difference.

In this case, we can perhaps think of the changing the thickness and the size of the rolled dough. We could also try to use different types of flour (atta, *maida*, etc.). While frying the *puri*, we can also change the temperature of the hot oil, or try and drop the rolled dough into the oil in different ways (drop it vertically? slide it at an angle? slide it slowly?) Notice that these are things that we can control.

However, to make sense of the changes, we also need to think of what we can observe or measure. Some of these may have just yes/no answers, in some cases there might be a number we can measure. Maybe we can start by checking whether the *puri* puffs up (yes/no), or we can measure the time it takes to puff up (seconds). We can check whether a very thick layer of dough still gives a thin side to the *puri*. Further, while doing such experiments, it is better to change only one thing at a time while keeping the other conditions same. For example, if we wanted to see the effect of boiling hot, hot, and not very hot oil, we would use circles of dough of the same thickness, and drop them in the same way. It is also a good idea to keep notes of everything that you see and sense when doing an experiment. Did the oil splatter, smell, or smoke? And after doing one round of experiments, you may think of more questions. Do *puri*s puff better when made fresh or from stored dough? What happens if I prick a hole in the *puri* before frying?

This is exactly how all scientific experiments, from simple to the most complicated are done. This is the idea of systematic investigation. And just so you know, even this simple everyday observation—of a *puri* swelling—is not really completely understood by scientists today!

So, whether it is the swelling of a *puri* or the shrinking bright part of the Moon after *purnima*, let your careful observations guide you along your explorations into the investigate world of science.

**Happy investigating!**

# The Invisible Living World: Beyond Our Naked Eye

# 2

## Probe and ponder

- Have you ever wondered what you might see if the invisible world around you became visible?
- How do you think your observation of this hidden world might change the way you think about size, complexity, or even what counts as 'living'?
- Have you thought how these tiny living beings interact with each other?
- Share your questions

______________________________

______________________________ ?

The human eye can only see objects that are above a certain size. For a long time, many tiny things around us remained unknown. Long ago, people discovered that a curved piece of glass could make small things look bigger. The piece of glass was shaped like a lentil seed—thick in the middle and thin at the edge—hence they called it a **lens**. Over time, lenses were improved to become more powerful. Each new tool, from simple magnifying glasses to microscopes, helped humans see what their eyes could not. The invention of the microscope opened a fascinating hidden world filled with tiny living creatures. We will **explore** some of these life forms in this chapter.

You have already learnt about the amazing variety of living beings. Just look around—there are so many beautiful plants and animals! They are of all shapes, sizes, and colours. Some living beings are tiny, while others are really big. They differ not only in their structure but also in many other features. All these living beings, whether plants or animals, are called **organisms**. Have you ever noticed the smallest organism around you that is visible to the naked eye? Think about it—how small a thing can your eyes actually see?

You might have seen some people using reading glasses. How does it help them see better? Or what happens when we use a magnifying glass to **observe** something?

## Activity 2.1: Let us observe

- Take a round-bottom flask made up of glass as shown in Fig. 2.1. Fill it with water.
- Close the mouth of the flask with a cork.
- Now, place the flask on an open book and look at the letters through it.

Do you notice something interesting? The letters appear larger when seen through the flask! This happens because the flask filled with water acts like a magnifying glass. Now, use a real magnifying glass to look at small organisms, like an ant. Were you able to see the details of its body more clearly?

For a long time, people were curious to explore the tiny organisms around them, but they could not see them with their naked eyes. So, how did we finally discover this invisible world? Do you know which scientific discovery helped us see the tiny world for the first time?

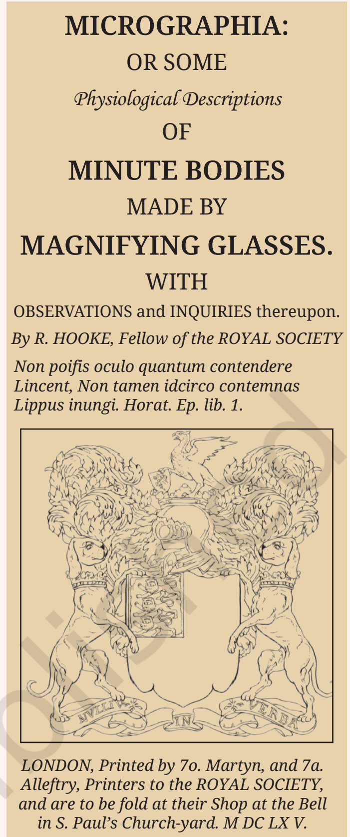
*Fig. 2.1: Round-bottom flask*

## Ever heard of ...

In 1665, a scientist named Robert Hooke published a book called *Micrographia*. He was a careful observer, and a skilled artist. In this book, he showed detailed drawings of tiny things that people had never seen before—things he saw using a tool we now call a microscope.

His microscope made things look 200 to 300 times bigger, than what one could see with the unaided eye. One day, he looked at a thin slice of cork and saw it was made of many small, empty spaces. These compartments reminded him of a honeycomb. He drew what he saw and called each small space a cell. This was the first time the word cell was used in science to describe the basic unit of life.

Around the same time in 1660s, Antonie van Leeuwenhoek, a Dutch scientist, made better lenses that allowed him to build more useful microscopes. He was the first person to clearly see and describe tiny living things like bacteria and blood cells. Because of this, he is known as the Father of Microbiology.


MICROGRAPHIA:
OR SOME
*Physiological Descriptions*
OF
MINUTE BODIES
MADE BY
MAGNIFYING GLASSES.
WITH
OBSERVATIONS and INQUIRIES thereupon.
*By R. HOOKE, Fellow of the ROYAL SOCIETY*
*Non poifis oculo quantum contendere Lincent, Non tamen idcirco contemnas Lippus inungi. Horat. Ep. lib. 1.*
*LONDON, Printed by 7o. Martyn, and 7a. Alleftry, Printers to the ROYAL SOCIETY, and are to be fold at their Shop at the Bell in S. Paul's Church-yard. M DC LX V.*

*(a)*

*(b)*

*(c)*

*Fig. 2.2: (a) Micrographia book; (b) Microscope of Robert Hooke; (c) Cork cells as published in the Micrographia*

## 2.1 What Is a Cell?

All living beings are made up of **cells**. You might wonder what cells actually look like. Let us take a closer look at the basic structure of a cell using a microscope.

## Activity 2.2: Let us study a cell (Teacher demonstration activity)

- Take an onion bulb from your kitchen or garden and wash it thoroughly with water.
- Cut the onion bulb vertically into pieces.
- Take one piece of onion and pull out the thin, transparent layer from its inner surface with the help of forceps. This layer is called the onion peel.
- Place the peel in a petri dish containing a few drops of safranin (red-coloured stain) for 30 seconds. This will give a pinkish colour to the cells and help us see them clearly.
- With the help of thin brush transfer the onion peel to another petri dish containing water to rinse the peel and remove extra stain.
- Now, carefully place the stained onion peel on the glass slide using a thin brush, ensuring it does not break or fold.
- Put a drop of glycerin over the onion peel on the slide. The glycerin will prevent drying of the cells and improve clarity for better visualisation of cells.
- Slowly place a coverslip over the peel using a needle, such that no air bubbles get trapped.
- Use blotting paper to gently wipe off any extra glycerin around the edges of the coverslip.
- View the slide under a microscope or a foldscope. **Compare** it with Fig. 2.3c.
- What similarities do you find in Fig. 2.3c and Fig. 2.3d?

You will observe nearly rectangular structures under the microscope. These are the cells of the onion peel, which are closely arranged without any space between them. Try to observe the peels of the leaves of different plants around you. You will find that all plants are made up of cells. What do you think the body of an animal is made of?

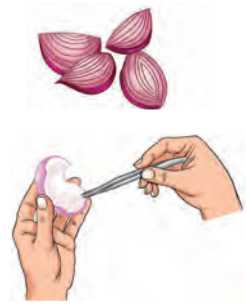
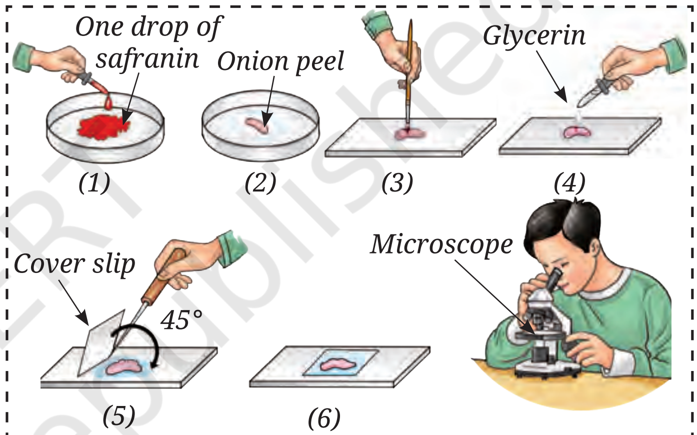
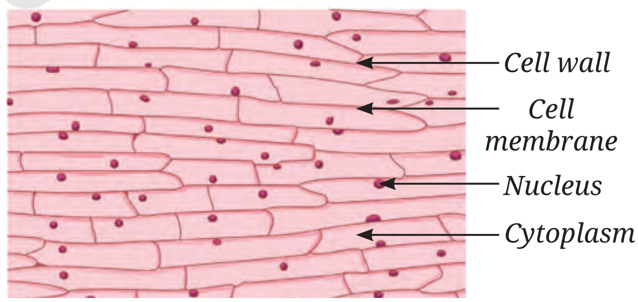


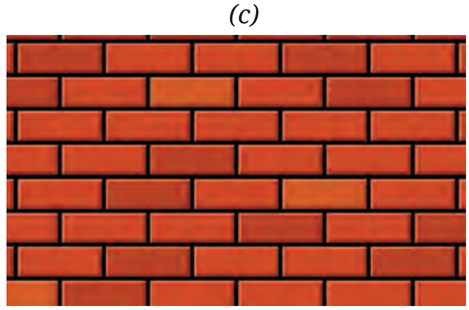
*Fig. 2.3: (a) Removing onion peel from an onion bulb*




(b)




(c)



(d)

*Fig. 2.3: (b) Mounting the onion peel in glycerin using a needle; (c) Structure of onion peel under the microscope; and (d) A wall made of brick*

## Activity 2.3: Let us investigate

- Rinse your mouth with clean water.
- Use the blunt end of a clean toothpick, and gently scrape the inside of your cheek.
- Place the scraped material in a drop of water on a clean glass slide and spread it evenly.
- Add a drop of methylene blue (a blue-coloured stain) over the material on slide. Adding stain improves the visibility of the material under the microscope by increasing contrast.
- After one minute, add a drop of glycerin over the material on the slide to prevent the cells from drying.
- Now, carefully place a clean coverslip on the material, and remove the excess glycerin from the edges of the coverslip using blotting paper.
- Observe the slide under a microscope and draw what you see in your notebook.

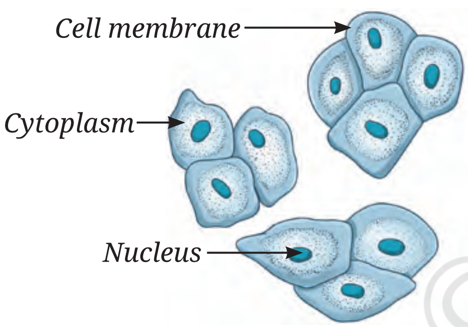



*Fig. 2.4: Mount of human cheek cells*

What did you observe? You will observe a polygon-shaped structure as shown in Fig. 2.4. These are cheek cells, which form the inner lining of your mouth.

What similarities and differences did you observe between the cells of onion peel in Activity 2.2 and human cheek cells in Activity 2.3?

You have observed that cells have three main parts —a thin outer lining, a central region, and a small round structure inside it. The outer layer is called the **cell membrane**. The round structure in the middle is the nucleus, which is also covered by a thin membrane. The space between the cell membrane and **nucleus** is filled with **cytoplasm**. These three—cell membrane, cytoplasm, and nucleus — are the basic parts of a cell. Some cells, like onion peel cells, have an extra outer layer called the **cell wall**. What is the importance of these structures in a cell? What functions do they perform? Are these functions important for the maintenance of life?

The cell membrane encloses the cytoplasm and nucleus. The cell membrane separates one cell from another. It is porous and allows the entry of materials essential for life processes and the exit of waste material.

Cytoplasm contains other components of the cell and compounds, such as carbohydrates, proteins, fats, and mineral salts. Most of the life processes take place within the cytoplasm.

The nucleus regulates all activities that occur within the cell. It also regulates growth.

The cell wall in the plant cell provides rigidity and strength to plants. This is why all cells are arranged compactly with each other and look firm in structure.

## A step further

Cells in all parts of a plant have tiny rod-shaped structures called **plastids**. Some plastids, like **chloroplasts**, contain chlorophyll, which makes them green and helps in photosynthesis. In non-green parts, they help in the storage of substances. Plant cells also have a large, empty-looking space called a **vacuole**. This helps the plant cell store important substances, get rid of waste, and maintain the shape of the cell. This gives strength and support to the plant. In animal cells, vacuoles are usually not present, if present, they are usually small. These small vacuoles store certain substances dissolved in water (Fig. 2.5). So, a cell is not just a simple bag of liquid—it is a complex structure made up of many different parts, each with its own special function to allow the cell, and in turn the entire organism to work.

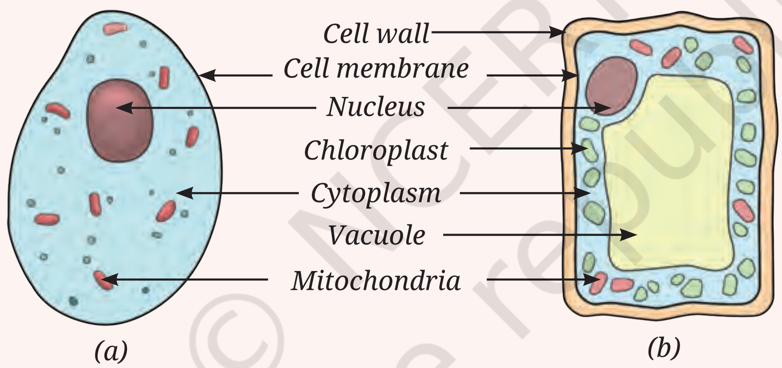



*Fig. 2.5: A schematic drawing of (a) An animal cell and (b) A plant cell. (The colours are to show different parts of the cell)*

We have now understood the basic structure of cell. And we now also understand that plant and animal cells differ in shape and structure.

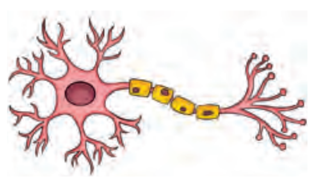
Do different animal cells also vary in their shape and structure?

### 2.1.1 Variation in shape and structure of cells

The **muscle** cell and the **nerve** cell of a human are shown in Fig. 2.6a and (b). What are the similarities and differences you see in them?

A muscle cell (Fig. 2.6a) is shaped like a spindle, while a nerve cell (Fig. 2.6b) is very long and has branches. Similarly, some cells are round in shape, while others are long and thin. The number of cells also varies in different organisms. Why do cells look so different from each other? Does the shape and structure of a cell relate to its function?

*(a) Muscle cell*



*(b) Nerve cell*

*Fig. 2.6: Different cells in humans*

The unique shape, size, and structure of cells help them carry out their specific functions. But how do these cells help in performing various functions in the body? Let us find out.

You observed in Activity 2.3 that inner cheek cells are thin and flat. They form a protective lining on the inner surface of the cheek. Nerve cells also known as **neurons** carry messages in our body. The elongated shape and branched structure help them reach different parts of the body and pass on messages quickly. Similarly, plant cells also show variation. In plants, too, cells may be rectangular, elongated, oval, or even tube-like. Some plant cells form long tubes that help carry water throughout the plant.

You have already studied the digestive system in Grade 7. Different parts of the digestive system are made up of different types of cells. A group of muscle cells are present in the food pipe. These cells contract and relax in a wave-like manner, pushing the food down to the stomach. This movement is possible because muscle cells are thin, flexible, and spindle-shaped. The stomach also has different types of cells for performing different functions. Muscle cells in the stomach wall help churn the food. Other cells in the inner lining of the stomach produce digestive juices and acid that help break down the food. All these cells work together to make digestion possible.

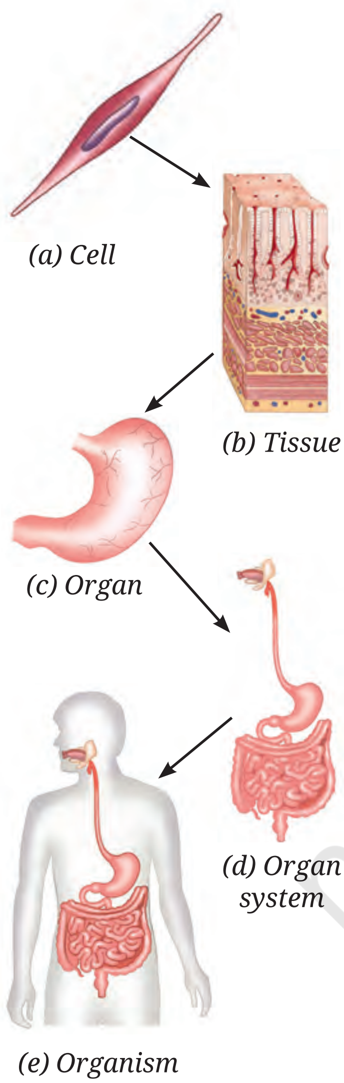



*Fig. 2.7: Levels of organisation of life*

## 2.2 What Are the Levels of Organisation in the Body of a Living Organism?

The body of a living organism is organised in a complex way. Cell (Fig. 2.7a), is the basic unit of life, just like a brick is the basic unit of wall (Fig. 2.3d). A group of similar cells forms a type of **tissue** (Fig. 2.7b). Different tissues are organised to form an **organ** (Fig. 2.7c). Several organs work together to form an **organ system** that performs a major function of the body (Fig. 2.7d). All the organ systems together make up a complete **organism** (Fig. 2.7e) — like a plant or an animal.

So, the levels of organisations are:

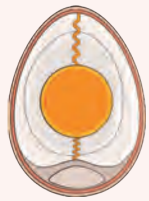
**Cell** → **Tissue** → **Organ** → **Organ system** → **Organism**

These levels of organisation help us understand how simple building blocks like cells come together to form a complex living being.

The life of complex living organisms begins with a single cell— 'egg'. The egg of any organism has an amazing ability to divide repeatedly to form a complete living being made up of many cells. Such living beings are called **multicellular organisms**. Animals, including humans, and plants are all examples of multicellular organisms.

## Ever heard of ...

The yolk (the yellow part of an egg) of an ostrich egg is a single cell—the largest known cell in the living world—measuring about 130 mm to 170 mm in diameter. The egg contains extra non-cellular material: a shell for protection and a white liquid that nourishes the cell during its continued development.



## 2.3 What Are Microorganisms?

Some living organisms are made up of just one or very few cells. They are so small that they can not be seen with the naked eye. These are called **microorganisms.** Some microorganisms, like bacteria and *Amoeba*, are made of just one cell (unicellular). Others, like some fungi and algae, have many cells (multicellular). They are found all around us—in water, soil, air, and even inside our body! But what do their cells look like? Are they like the plant and animal cells we just learnt about, or are they different? To observe the cells of a microorganism, again, we need to use a microscope which magnifies their size and makes them visible to us. Scientists have also created a low-cost and foldable paper microscope or foldscope. Foldscopes may not provide the same level of details like high-powered laboratory microscopes. However, these make microscopic world accessible to many people.

Let us now take a closer look at the fascinating world of microbes.

### Activity 2.4: Let us observe pond water/ stagnant water

- Take a container and collect pond or stagnant water in it with the help of your teacher or elder(s).
- Use a dropper and place a drop of pond or stagnant water on a microscope or foldscope slide. Put a coverslip and observe it under the microscope or foldscope.
- Observe the tiny organisms found in the pond or stagnant water.

### Activity 2.5: Let us observe soil suspension

- Take a beaker and collect some moist soil in it from the nearby field or garden. Do not touch the soil with your bare hands—use a spoon or gloves.

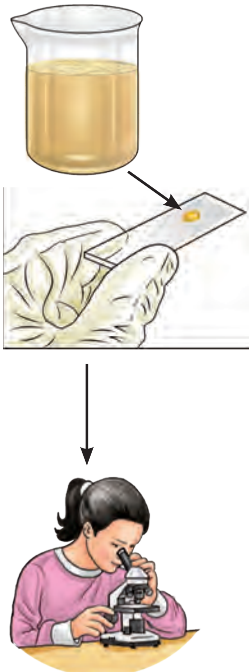


*Fig. 2.8: Observation of soil suspension under the microscope*

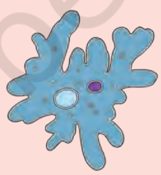
- Pour some water into the beaker and stir it with a glass rod. The liquid, which may look dirty, has very fine particles of soil, and is called soil suspension. Keep it aside for some time and let the mixture settle.
- Use a dropper and take a drop of water from the top layer. Place the drop on a microscope slide.
- Cover it gently with a coverslip and observe it under the microscope (Fig. 2.8).

You may observe small moving organisms similar to those you saw in Activity 2.4. This indicates that even **soil suspension** contains a variety of tiny creatures that cannot be seen with the unaided eye. The tiny creatures that cannot be seen with the naked eye are called microorganisms (micro means very small; organisms means living beings) or **microbes**.

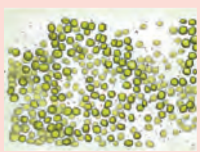
## Activity 2.6: Let us study

A group of students studying in Grade 8 performed Activities 2.4 and 2.5. They also collected information from the library and internet. They recorded the data obtained after observing pond water in Table 2.1 and the data obtained after observing soil suspension in Table 2.2. They identified the microorganisms as protozoa, algae, fungi, and bacteria. You can record if you find any of these categories of organisms.

**Table 2.1: Organisms present in pond water**

| S.No. | Diagram | Remarks |
|---|---|---|
| 1. | *Amoeba* (Protozoa)  | Single cell, moving, irregular shape |
| 2. | *Paramecium* (Protozoa)  | Single cell, moves from one place to another, movement takes place with the help of specialised structures |
| 3. | Algae  | Single cell, looks green because of the presence of green pigment, movement takes place with the help of specialised structures |

## Table 2.2: Organisms present in soil suspension

| S.No. | Diagram | Remarks |
|---|---|---|
| 1. | Bread mould (Fungi)  | Branched filament without chlorophyll having sac-like structure |
| 2. | Mould (Fungi)  | Branched filament without chlorophyll having brush-like structure |
| 3. | Algae  | Spherical, presence of chlorophyll—a green pigment |
| 4. | Bacteria  | Spherical, comma, spiral or rod-shaped, one long hair-like structure and many small hair-like projections around the cell |

Did you also observe any of these microorganisms or something different? Record in your notebook and discuss in your class. In Tables 2.1 and 2.2, you have identified a variety of microorganisms. They are everywhere, and we can only see them with a microscope—a device that magnifies them 100 to 400 times. Though microorganisms are small in size, they play an important role in our lives.

### Ever heard of ...

**Viruses** are microscopic and acellular. Viruses multiply when they enter a living cell. They may infect plants, animals, or bacterial cells and may cause a disease.

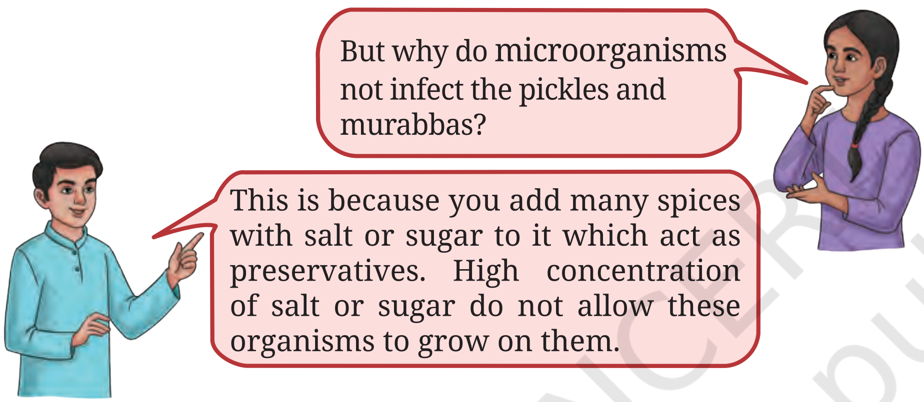
## 2.4 How Are We Connected to Microbes?

*Fig. 2.9: Fruit with microorganism growing on it*

Can we find microorganisms in other places, too? Let us have a discussion:

Have you ever seen a lemon, tomato, orange, or any other food item rot after being left outside for some time? If yes, you may have noticed a powdery or cotton-like growth on them (Fig. 2.9). This happens because they have been infected by microbes. But where did these microbes come from? How did they come in contact with the food?

This happens because microorganisms can be found everywhere, be it in water, soil, air, or even in some food items.




You can use a foldscope or a microscope to explore surfaces of leaves, stems, roots, or any other part to see them. Like plants and animals, microorganisms also show great diversity. Some of them can even be found in extreme climatic conditions, such as hot water springs and snow cold zones as well as at moderate temperatures. You already know some of these organisms live inside our bodies, especially in our gut! You have studied in the chapter 'Life Processes in Animals' in *Curiosity*, Grade 7 that our intestine has many bacteria that help in digestion. Like plants and animals, microorganisms vary in shape, size, and structure. In Tables 2.1 and 2.2, you would have observed microorganisms of different shapes—spherical, rod-shape, or irregular.

How does the diversity of microorganisms play a role in our daily life? How do they help clean the environment?

### 2.4.1 Key players in cleaning the environment

Let us attempt to understand this by doing an activity.

### Activity 2.7: Let us do

- Take an empty container and fill it halfway with garden soil.
- Add some fruit and vegetable peels to the container. Thereafter, put a layer of soil on it and leave it aside.

- After 2–3 weeks, observe the changes that have taken place.
- Do you observe any difference in the contents of the container?

You may find that peels of fruits and vegetables have turned into a dark-coloured material. This is **manure**, which is rich in nutrients and helps increase the fertility of the soil. But how did the peels of fruits and vegetables turn into manure?

*Fig. 2.10: Recycling of nutrients by making manure*

In Activity 2.6, you saw that soil contains various kinds of microorganisms. Some of these microorganisms, like fungi and bacteria, act on the plant waste and slowly break it down into simpler, nutrient-rich manure. You may have seen gardeners in your school or in a field near your house collecting dry leaves and plant waste and putting them into pits. Do you now understand why they do this? It is to make natural manure.

## Our scientific heritage

Ancient Indian texts, particularly the Vedas, have references of the word '*Krimi*' which means different tiny entities including '*Drishya*' (visible) and '*Adrishya*' (invisible). Various Vedic texts mention their beneficial and harmful effects.
Atharvaveda also refers to '*Krimi*'.

If you look around carefully, you might see decaying plants and fallen leaves stored in a container or lying in the garden, disappear after some time from the surroundings. This is because microorganisms breakdown and turn them into simpler substances rich in nutrients. These nutrients go back to the soil and help plants grow better. Microorganisms also decompose bodies of dead animals. So, microbes help recycle the waste and return important nutrients to nature. Manure formation occurs at optimal temperature and appropriate moisture level.

Isn't it interesting? By now, you must have understood that bacteria and some fungi are types of microorganisms that play an important role in our lives. And guess what, these helpful bacteria can also decompose animal wastes like dung!

From Activity 2.7, we can also infer that microorganisms not only help in plant growth, but also clean our environment by breaking down waste.

Now, think what would have happened if microorganisms did not exist on Earth?

## A step further

**Microbes as a source of biogas**

Many microorganisms, like bacteria and fungi, live in an oxygen-free environment. Some of these bacteria have the ability to decompose plant and animal waste present in the environment or household wastewater. During the process, they release a mixture of gases containing carbon dioxide, and a high proportion of another gas, methane. This gas has been used as a fuel source for cooking, heating, generating electricity, and to even run vehicles.

## Be a scientist

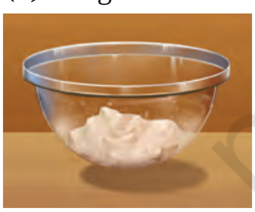
Dr. Ananda Mohan Chakrabarty (1938–2020) was a scientist who studied bacteria. In 1971, he developed a special bacterium that could break down oil spills, helping to clean the environment. His discovery received a patent in 1980. **Patent** is a copyright given to a person so that no one else can copy, use or sell his/her invention without permission. His work showed how microorganisms could be used to solve environmental problems like pollution. He is remembered for his contributions to science and for protecting the environment using microbes. What are the other problems which you think can be solved with the help of microorganisms?

How does the diversity of microorganisms help in our kitchen?

### 2.4.2 Microorganisms and food

Let us try to understand by performing activities in the kitchen.

*(a) Dough in bowl A*



*(b) Dough in bowl B*

*Fig. 2.11: Change in the volume of flour after addition of yeast, sugar, and warm water*

## Activity 2.8: Let us perform

- Take two bowls A and B.
- In each, take 200 g of flour (atta or *maida*) and add a pinch of sugar.
- Now, in bowl A, add a small amount of yeast powder and mix it well with the flour.
- In bowl B, do not add any yeast, so that we can compare the results of the two bowls.
- Knead the flour of the two bowls with warm water to make soft dough (Fig. 2.11).

- Cover the dough with a damp cloth and keep it in a warm place.
- Observe both the bowls after 4–5 hours.

Did you find any change in the volume, smell, or texture of the dough? If not, leave the dough for some more time. After some time, you may notice that the dough in bowl A, where yeast was added, has risen slightly, become fluffy, and has a different smell compared to the dough kneaded without yeast. Why does this happen? What is the role of yeast? Why did we add sugar and warm water to the flour?

Yeast is a type of microorganism. It belongs to a group of microorganisms, called **fungi**. Yeast grows well in warm conditions. You may recall from chapter 'Life Process in Animals' in Grade 7 that, like other organisms, yeast also respires and breaks down food to release energy for their growth and carry out life processes. During this process, carbon dioxide is released, which forms bubbles that makes the dough soft and fluffy. Yeast also produces a small amount of alcohol during this process, which gives the dough a slightly different smell. This special property of yeast is used in the process of making breads, cakes, and more! In addition to yeast, some bacteria, such as *Lactobacillus*, help in fermentation of batter for making idli and dosa, and dough for making *bhatura*.



## Activity 2.9: Let us prepare

- Take two small glass bowls—label them 'A' and 'B'.
- Pour lukewarm milk in bowl A, and cold milk in bowl B.
- Now, add a small spoonful of curd to each bowl and mix well using a spoon.
- Cover both bowls. Keep bowl A in a warm place and bowl B in a cool place (like a refrigerator) for a few hours or overnight.
- Observe the changes in the glass bowls. Write your predictions and observations in Table 2.4.

**Table 2.4: Testing for curd formation using milk in different conditions**

| | Change in the appearance of milk | | Change in the colour of milk | | Possible reason |
|---|---|---|---|---|---|
| | Bowl A | Bowl B | Bowl A | Bowl B | |
| Prediction | | | | | |
| Observation | | | | | |

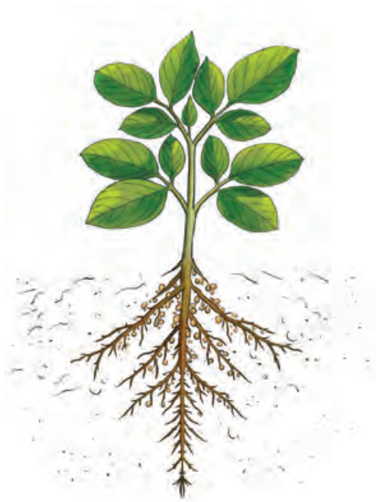


*Fig. 2.12: Root nodules of Cowpea plant which contain Rhizobium*

You will observe that in bowl A, the milk has turned into curd after a few hours and has become little sour. Whereas in bowl B, the milk has not curdled, but it might be a little sour. Do you know why this happens? The curd contains several types of bacteria. One of them is *Lactobacillus*. This bacterium feeds on the sugar in the milk (lactose), multiplies, and ferments the milk to form curd. Instead of producing alcohol (like yeast), these bacteria produce lactic acid, which makes curd sour. These bacteria grow well in warm conditions. That is why curd is formed in bowl A but not in bowl B.

We can categorise the microorganisms into different categories, such as protozoa, fungi, bacteria, some algae, and more. Some bacteria, such as *Rhizobium*, form the swollen regions called nodules and live in them as shown in Fig. 2.12. Roots of certain legumes, such as beans, peas, and lentils have root nodules that contain *Rhizobium* bacteria. These bacteria trap nitrogen from the air and make it useful for the plants. This helps plants grow better without chemical fertilisers. That is why farmers grow legumes in rotation with other crops. This naturally increases the nitrogen in the soil and keeps it healthy for the next crop.

### 2.4.3 Amazing microalgae: tiny helpers in water

Microalgae are microscopic plant-like organisms that live in water, soil, air, and even on trees. They make their own food using sunlight. While doing this, they also release oxygen and produce more than half of the Earth's oxygen supply. They are rich in nutrients and serve as a food source for many aquatic animals. Some, like *Spirulina*, *Chlorella*, and Diatoms, are also used by humans as health supplements and medicines. Microalgae also help in cleaning water and are used to make biofuel.

However, pollution, climate change, and habitat destruction are threatening microalgal diversity and abundance. It is important to conserve these tiny organisms to protect the environment and maintain oxygen balance on Earth.

## Ever heard of ...

*Spirulina*, a microalga, is called a superfood because of its health benefits. *Spirulina* is also a good source of vitamin B12, which is essential for our body. It has a lot of protein—more than 60 per cent of its body weight—and only a small amount of fat and sugar.

Nowadays, farming of *Spirulina* is becoming a feasible livelihood opportunity. You can grow *Spirulina* easily by following these steps:

1. Set a clear glass tank in a bright place away from direct sunlight.
2. Cover the tank with a shade net, or keep the tank at a place with moderate temperature conditions.
3. Fill the tank with pond water.
4. Add living *Spirulina* collected from a pond.
5. Stir the growing *Spirulina* twice a week.
6. After 3–6 weeks, *Spirulina* may be harvested from the tank by filtering it through a fine cloth.

Conservation of microalgae is a good practice for ensuring food security and livelihood development.



## 2.5 Why Is Cell Considered to Be a Basic Unit of Life?

The body of all living organisms are made up of tiny building blocks called cells. A single cell contains various components that help organisms perform various functions. The bodies of all plants and animals are made up of many cells. Therefore, they are called **multicellular** (many-celled) organisms. In multicellular organisms, cells carry out specialised functions individually but also cooperate with each other to increase the chance of survival.

Some microorganisms, such as bacteria and protozoa, are made up of just one cell. These are called **unicellular** (single-celled) organisms. They carry out all the functions necessary for their survival in a single cell. Other microbes, like algae and fungi, are made up of one or more cells. For example, yeast is a unicellular fungus while mould is a multicellular fungus.

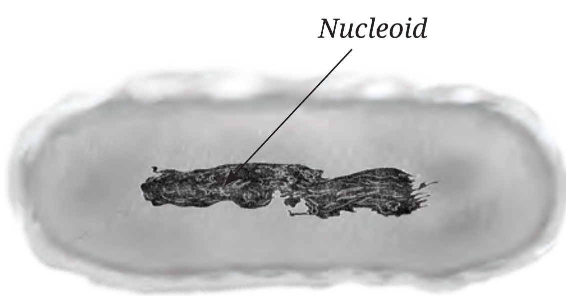



*Fig. 2.13: A bacterial cell showing the nucleoid region*

Like animal and plant cells, the cells of microorganisms are also surrounded by a cell membrane. Cells of fungi additionally have a cell wall, but they do not have chloroplasts, so they cannot make their own food through photosynthesis. Bacteria do not have a well-defined nucleus and a nuclear membrane. Instead they have a nucleoid. This feature distinguishes them from cells of yeast, protozoa, algae, fungi, plants, and animals.

We have only looked at a few basic cell structures here. The cell has other components about which you will learn in higher classes. For observing subcellular components, we need microscopes with high magnification. An electron microscope magnifies the cell about 10,00,000 times, where we can see more structures present in a cell.

By now, you must have understood that all living beings, including microorganisms, are made up of one or more cells. Their cells differ in size, shape, and structure. Plant and animal cells also have some differences. Understanding these differences helps us learn how these organisms function differently.

In this chapter, we have learnt about the beneficial microorganisms. However, there are some microbes that cause diseases in plants and animals including humans. We will learn about some of the diseases caused by microbes in the next chapter.

## Snapshots

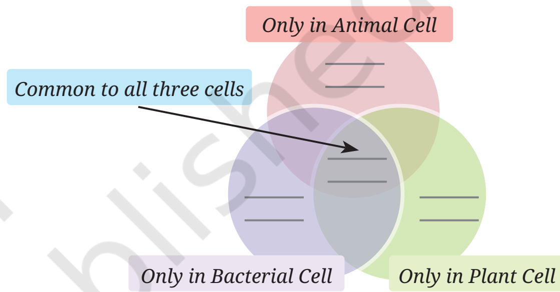
- Microorganisms are small-sized organisms and are not visible to the unaided eye.
- They can live in all kinds of environments, and even in the bodies of plants and animals.
- They are either unicellular or multicellular. Bacteria and protozoans are unicellular; fungi can be unicellular or multicellular, while plants and animals are multicellular.
- The cell is a basic unit of life.
- The body of all living organisms is made up of cells. A cell contains various components which help the organisms perform their functions and survive.
- A typical cell is bounded by a cell membrane, filled with cytoplasm and contains a nucleus. Plant, fungal, and bacterial cells have an extra covering, called a cell wall, around the cell membrane. Bacteria lack a well-defined nucleus.
- Cells differ in shape and size. Their shape is related to the function performed by them.
- Bacteria, fungi, and protozoa are different kinds of microorganisms.
- Viruses are also small in size, but they are different from other microorganisms since they reproduce only inside the host organism.

- Microorganisms can be beneficial or harmful to us.
- Some microorganisms decompose the plant and animal waste into simple substances and clean up the environment.
- Some microorganisms reside in the root nodules of legumes, such as peas, beans, and lentils. They trap nitrogen from the air and increase the soil fertility.
- Yeasts are fungi which are used in the process of making breads, cakes, pastries, idlis, dosas, and bhaturas.
- *Lactobacillus* is used in the curd formation at home and fermentation process in food industry.

## Keep the curiosity alive

1. Various parts of a cell are given below. Write them in the appropriate places in the following diagram.

   Nucleus — Cytoplasm
   Chloroplast — Cell wall
   Cell membrane — Nucleoid




2. Aanandi took two test tubes and marked them A and B. She put two spoonfuls of sugar solution in each of the test tubes. In test tube B, she added a spoonful of yeast. Then she attached two incompletely inflated balloons to the mouth of each test tube. She kept the set-up in a warm place, away from sunlight.
   (i) What do you predict will happen after 3–4 days? She observed that the balloon attached to testtube B was inflated. What can be a possible explanation for this?
   (a) Water evaporated in test tube B and filled the balloon with the water vapour.
   (b) The warm atmosphere expanded the air inside the test tube B, which inflated the balloon.
   (c) Yeast produced a gas inside the test tube B which inflated the balloon.
   (d) Sugar reacted with warm air, which produced gas, eventually inflating the balloon.
   (ii) She took another test tube, 1/4 filled with lime water. She removed the balloon from test tube B in such a manner that the gas inside the balloon did not escape. She attached the balloon to the test tube with lime water and shook it well. What do you think she wants to find out?

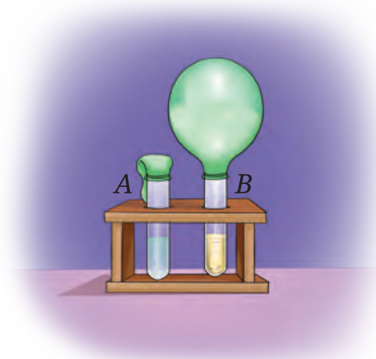



*Fig. 2.14: Experimental set-up*

3. A farmer was planting wheat crops in his field. He added nitrogen-rich fertiliser to the soil to get a good yield of crops. In the neighbouring field, another farmer was growing bean crops, but she preferred not to add nitrogen fertiliser to get healthy crops. Can you think of the reasons?
4. Snehal dug two pits, A and B, in her garden. In pit A, she put fruit and vegetable peels and mixed it with dried leaves. In pit B, she dumped the same kind of waste without mixing it with dried leaves. She covered both the pits with soil and observed after 3 weeks. What is she trying to test?
5. Identify the following microorganisms:
   (i) I live in every kind of environment, and inside your gut.
   (ii) I make bread and cakes soft and fluffy.
   (iii) I live in the roots of pulse crops and provide nutrients for their growth.
6. Devise an experiment to test that microorganisms need optimal temperature, air, and moisture for their growth.
7. Take 2 slices of bread. Place one slice in a plate near the sink. Place the other slice in the refrigerator. Compare after three days. Note your observations. Give reasons for your observations.
8. A student observes that when curd is left out for a day, it becomes more sour. What can be two possible explanations for this observation?
9. Observe the set-up given in Fig. 2.15 and answer the following questions.
   (i) What happens to the sugar solution in flask A?
   (ii) What do you observe in test tube B after four hours? Why do you think this happened?
   (iii) What would happen if yeast was not added in flask A?

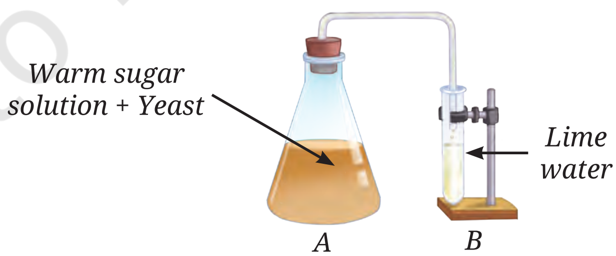



*Fig. 2.15 : Experimental set-up*




**Prepare some questions based on your learnings so far ...**

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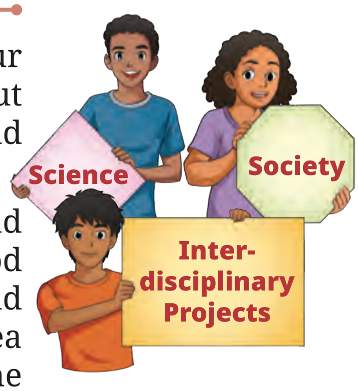
## Discover, design, and debate




- India has a long history of biogas production. One of our oldest biogas plant was set up in late 1850s. Find out about the Biogas Program initiated by the Ministry of New and Renewable Energy, Government of India.
- Fermented food items like fermented soybeans and fermented bamboo shoots are consumed as traditional food in some parts of India. With the help of your parents and teachers, list some traditional food items from your area that utilise the process of fermentation. Investigate the ingredients used in the preparation of these fermented food items; the method of preparing them; the microorganism responsible for the fermentation of the food, and the cultural and nutritional importance of the fermented food.
- Study the different parts of a macro fungus mushroom using a magnifying glass and microscope/foldscope. Take the help of students from senior classes and explore the internal structure of different parts of mushrooms under the microscope/foldscope in your school laboratory.
- Interact with an entrepreneur and learn the steps for cultivation of mushroom.



**Reflect on the questions framed by your friends and try to answer ...**

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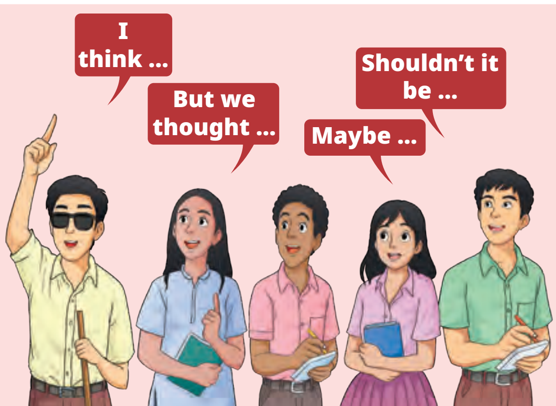

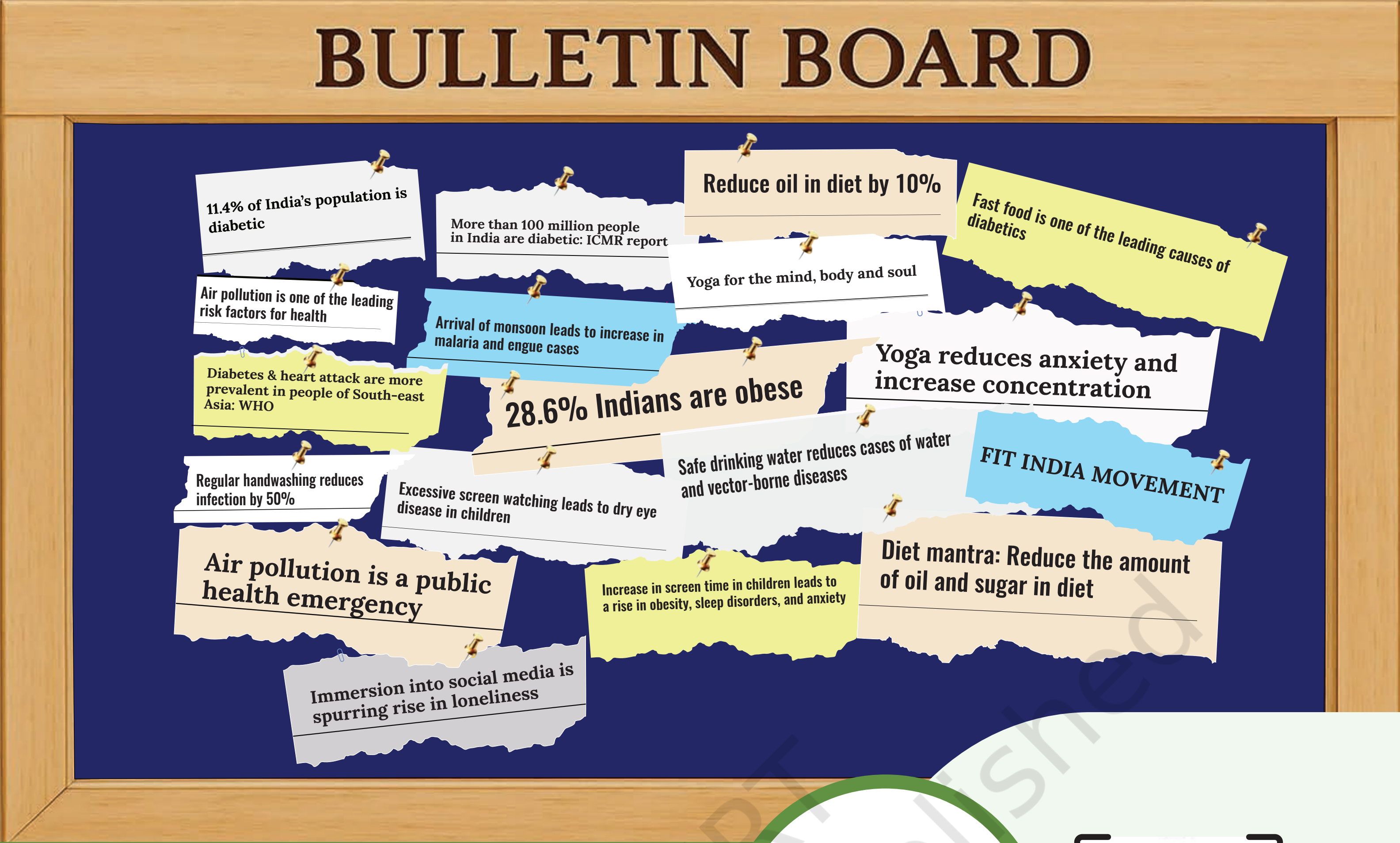


# 3 Health: The Ultimate Treasure

0877CH03

## Probe and ponder

- How does your body respond to an infection such as common cold?
- We rarely see cases of smallpox or polio these days, but diseases like diabetes and heart problems are more common. Why?
- Could climate change lead to new types of diseases?
- How do emotions like stress or worry affect us and make us sick?
- Why do some groups of people get affected more than others during disease outbreaks?
- Share your questions

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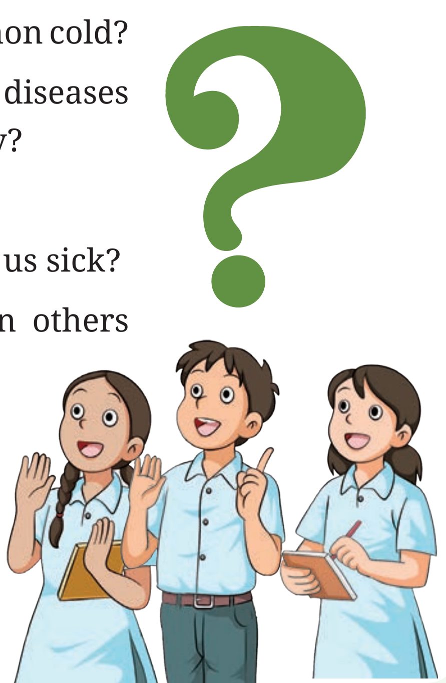


## 3.1 Health: Is It More Than Not Falling Sick?

What do the news clippings on the notice board tell you about people's health in our country? Is being healthy just about not having diseases? Health also includes feeling good physically, staying positive, and having strong relationships. A healthy person takes care of their body, maintains a positive mindset, and enjoys social life. Let us now **explore** what it truly means to be healthy.

### Activity 3.1: Let us read

A Grade 8 student moved to a new school in another city. With no friends in his new environment and busy parents, he felt lonely. To cope, he spent more time on his phone and social media, but this made him feel worse. He stopped trying to make friends, had headaches, lost weight, and could not sleep well. A doctor advised less screen time and meeting a counsellor. The school counsellor arranged help to support him in making friends and improving his health.

**Think** and **Reflect**: What was the cause of the boy's health problems? How did his habits and surroundings affect his well-being?

As per the World Health Organization (WHO), health is defined as a 'state of complete physical, mental, and social well-being, and not merely the absence of disease' (Fig. 3.1). A healthy person can perform various tasks more efficiently and cope well in different and difficult situations. A healthy person can adjust well with peer groups and other members of society. Let us understand more about health.


*Fig. 3.1: Aspects of health*

### Our scientific heritage

Ayurveda teaches us that true health is a balance of body, mind, and surroundings.

Following *dinacharya* (daily routine) and *ritucharya* (seasonal routine) helps maintain this balance. Eating fresh, wholesome food suited to one's *prakriti* (body constitution) is essential. Regular exercise, cleanliness, restful sleep, and a calm mind support overall well-being. This can also be achieved through practices like yoga, meditation, and mindfulness.

## 3.2 How Can We Stay Healthy?

Staying healthy means eating nutritious food, maintaining hygiene, staying in a clean place, exercising regularly, getting proper sleep, spending time with family and friends, and having a positive attitude. What we should do and what should not do to keep ourselves healthy?

## Activity 3.2: Let us list

- List some good habits that your parents, teachers, or elders often encourage you to follow. How many of these are already a part of your daily routine? Which ones would you like to start following? Add to the list below:
    - Keep yourself clean and maintain personal hygiene.
    - Eat a healthy and balanced diet.
    - Exercise regularly.
    - Make time to relax or meditate every day.
- Now, think about habits that are not good for your health. Add more to the list below:
    - Spending too much time on mobile phones or other digital screens.
    - Eating fast food and other junk food every day.
    - Sleeping very late or not getting enough sleep.
    - Skipping meals, especially breakfast.

Taking care of our body and mind is important. Healthy habits support a healthy body as well as a healthy mind.

Discuss your findings with your friends and teacher. From the activity you participated in and the discussions, you may have realised that our health depends on many factors. These factors include our lifestyle (how we live) and our environment (our surroundings).

### 3.2.1 Maintain a healthy lifestyle

- Eat a balanced diet with plenty of fruits, vegetables, and whole grains.
- Avoid processed, fatty, or sugary food and drinks.
- Stay physically active by playing outdoors, walking, running, cycling, or exercising.
- Limit screen time and spend more time in nature.
- Get enough sleep to help your body and mind rest and recover.
- Practice yoga or simple breathing exercises like pranayama regularly.
- Say 'NO' to harmful substances things like tobacco, alcohol, and addictive drugs (Fig. 3.2).

*Eat a balanced diet*

*Stay physically active*

*Say no to smoking or alcohol*

*Manage stress*

*Get enough sleep*

*Fig. 3.2: How to be healthy*

### 3.2.2 Keep the environment clean

## Activity 3.3: Let us compare

- Look at Fig. 3.3a and Fig. 3.3b. Which playground would you like to play in, and why?
- Most of us would like to play in the playground shown in Fig. 3.3a as it is clean, well-maintained, and looks beautiful. The playground in Fig. 3.3b is polluted, dirty, unhygienic, and full of flies and mosquitoes. People living in such areas may fall sick more often.
- In addition to inculcating good habits and adopting a healthy lifestyle, we must keep ourselves and our surroundings clean.
- Have you ever found it hard to breathe in a place with a lot of smoke or dust? That is because clean air and water are important for our health. In cities, air pollution from vehicles and factories can cause problems like coughing or asthma. The **Air Quality Index** (AQI) helps us know how clean the air is. A cleaner environment helps us stay healthy and feel better.
- But health is not only about the body. Our feelings and relationships matter too. Even if we eat well and live in a clean place, we may not feel good if we are lonely or upset. Spending time with friends and family, talking, laughing, and having fun help keep our minds healthy too.

*(a)*

*(b)*

*Fig. 3.3: Two different playgrounds*

## 3.3 How Do We Know That We Are Unwell?

Our body usually works in a certain way to keep us healthy. When we feel unwell, it means something inside us may not be working as it should. We may have symptoms, such as pain, tiredness, or dizziness, and signs like fever, rash, high blood pressure, or swelling that indicate we are unwell. A symptom is what we feel (like pain), while a sign is something that can be seen or measured (like high body temperature when we have fever). These help doctors understand what might be making us unwell.

## 3.4 Diseases: What Are the Causes and Types?

A disease is a condition that affects the normal working of the body or mind. It can happen when one or more organs or organ systems stop functioning properly. Some diseases are caused by germs like bacteria, viruses, fungi, worms, or even by protozoa (single-celled organisms). These disease-causing organisms are called **pathogens**. Other diseases may result from poor nutrition or an unhealthy lifestyle. Some diseases last for a short time, while others can continue for a long time and need regular treatment or care. Diseases can be grouped into two major types based on their causes and how they spread:

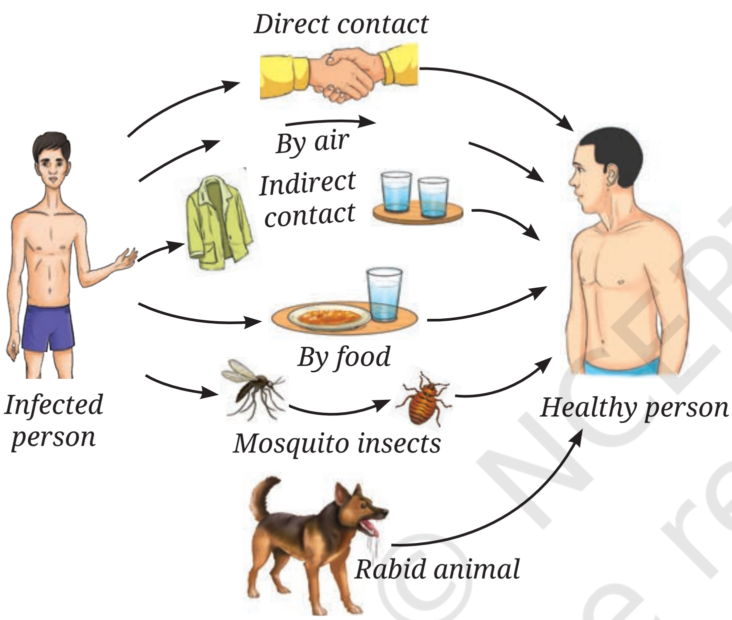



*Fig. 3.4: Common methods of transmission of diseases*

- **Non-communicable diseases**— Some diseases, like cancer, diabetes, or asthma, are not caused by pathogens and do not spread from one person to another. They are usually linked to lifestyle, diet, and/or environment.
- **Communicable diseases**— Diseases caused by pathogens are called communicable diseases. They can spread from one person to another. Some examples of communicable diseases are typhoid, dengue, flu, chickenpox, and COVID-19.

In recent years, non-communicable diseases (NCDs) like diabetes, heart disease, and cancer have become more common in India. This is happening because of changes in how people live—such as eating more processed food, getting less exercise, and living longer lives. Today, most deaths in India are caused by NCDs. Understanding the difference between these two types helps us know how diseases spread and how to prevent them.

### 3.4.1 How are communicable diseases caused and spread?

All communicable diseases are caused by pathogens. These pathogens can enter our body through the air we breathe or by consuming contaminated food or water and more. But how do these pathogens spread from one person to another? One common way is through air, when an infected person coughs or sneezes, or through direct contact like shaking hands, or indirectly by sharing personal items of an infected person. Some of the communicable diseases spread through contaminated drinking water or food. Some pathogens are also spread by insects like mosquitoes and houseflies—these insects are called **vectors** (Fig. 3.4).

By understanding how diseases spread, we can take simple steps to protect ourselves and others. Let us find out how these communicable diseases spread and how we can prevent them.

## Activity 3.4: Let us find out

- Grade 8 students listed some common communicable diseases in Table 3.1 during a community campaign and a library survey.
- Check the information listed by referring to books, trusted websites, or asking your science teacher. Add any missing details.
- Study the table and think about what simple steps can help prevent each disease.

**Table 3.1: Some common communicable diseases affecting humans**

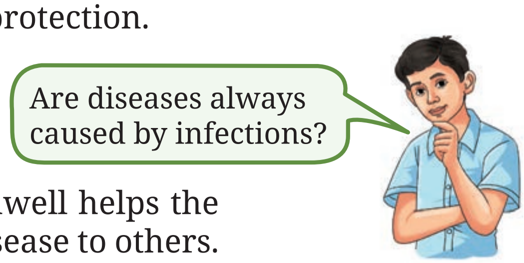
| Diseases | Causal agent | Site of infection | Symptoms | Preventive measures |
|---|---|---|---|---|
| **Diseases spread through the air** | | | | |
| Common cold and influenza  | Virus | Respiratory tract | Nasal congestion and discharge, sore throat, fever, cough, body ache | Washing hands frequently, not sharing personal items, covering the mouth and nose |
| Chickenpox  | Virus | Respiratory tract, skin | Mild fever, itchy skin, rashes, blisters | Complete isolation of the patient, covering the mouth and nose, vaccination |
| Measles  | Virus | Skin, respiratory tract | Fever, sore throat, and reddish rashes on the neck, ears and other parts of the skin | Isolation of the patient, covering the mouth and nose, maintaining good hygiene, vaccination |

| | | | | |
|---|---|---|---|---|
| Tuberculosis (TB)  | Bacteria | Lungs | Cough, fever, fatigue, loss of appetite, night sweats | Avoiding close contact with TB-infected people, covering the mouth and nose, maintaining good hygiene, getting vaccinated |
| **Diseases spread through contaminated water and food** | | | | |
| Hepatitis A  | Virus | Liver | Fatigue, fever, loss of appetite, nausea, vomiting, jaundice, pain in the upper right abdomen | Drinking boiled water, vaccination |
| Cholera  | Bacteria | Intestine | Diarrhoea and dehydration | Maintain personal hygiene and good sanitary habits, consumption of properly cooked food and boiled drinking water, vaccination |
| Typhoid  | Bacteria | Intestine | Headache, abdominal discomfort, fever, and diarrhoea | Maintain personal hygiene and good sanitary habits, consumption of properly cooked food and boiled drinking water, vaccination |
| *Ascariasis* (roundworms)  | Worms | Intestine | Worms in stool, loss of appetite, poor growth, diarrhoea, weight loss, anaemia | Maintain personal hygiene and good sanitary habits, consumption of properly cooked food and boiled drinking water |

| | | | | |
|---|---|---|---|---|
| **Diseases transmitted by insects** | | | | |
| Malaria  | Protozoa | Skin, blood | High fever, profuse sweating, periodic chills | Use of mosquito nets and repellents, wearing long–sleeved clothes, control of mosquito breeding in and around your home |
| Dengue fever (Break bone fever)  | Virus | Skin, blood | Fever, headache, muscle and joint pain, nausea | Use of mosquito nets and repellents, wearing long-sleeved clothes, control of mosquito breeding in and around your home, avoiding areas with still water |

By studying the Table 3.1, we can understand how infectious diseases spread and how to prevent them. Here are some simple but important precautions:

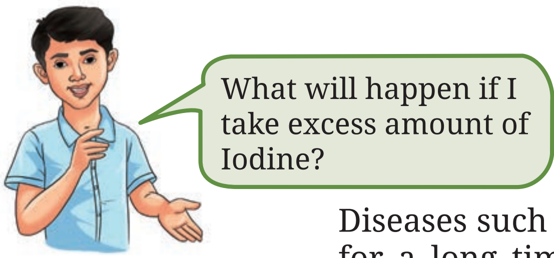
- Keeping ourselves and our surroundings clean.
- Practising basic hygiene every day.
- Washing hands with soap and water to remove pathogens.
- Covering our mouth and nose while coughing or sneezing.
- Wearing a mask in crowded places provides protection.
- Avoid sharing of personal items like towels and handkerchiefs.
- Keeping our home, food, and water clean.
- Staying at home and resting when we are unwell helps the body recover and minimises spreading the disease to others.




Some infectious diseases are caused by worms that live inside our bodies, especially in the digestive system. They feed on nutrients and live as **parasites**—organisms that live in or on another living being. These worms usually spread through contaminated food, water, soil, or contact with infected people or animals.

### 3.4.2 How are non-communicable diseases caused?

You learnt that non-communicable diseases like cancer, diabetes, and asthma are linked to lifestyle, diet, and/or environment. They are the most common cause of death in India. In Grade 6, you also learnt about diseases like scurvy, anaemia, and goitre,




which are caused by a lack of specific nutrients in the diet. These are called **deficiency diseases** and are also non-communicable.

Diseases such as cancer, diabetes, and asthma may often persist for a long time (more than 3 months) and are referred to as **chronic diseases**.

Diabetes is a common disease which is becoming more prevalent in adults as well as children. In fact, India now has one of the highest numbers of people with diabetes in the world. It often develops due to a combination of hormonal imbalances, unhealthy eating habits, lack of physical activity, being overweight or obese, and other reasons.

Let us learn more about the causes of non-communicable diseases and their prevention.

## Activity 3.5: Let us survey

- Find out the three most common lifestyle-related diseases in your neighbourhood
- Talk to a doctor, nurse, health worker or even a family member who knows about health and what kind of lifestyle changes can help prevent or manage these diseases.
- You can also consult trusted health websites, books, teachers and doctors.
- Fill in Table 3.2 and learn more about lifestyle-related diseases.

**Table 3.2: Non-communicable diseases**

| S. No. | Name of common lifestyle-related diseases | Signs and symptoms | Suggested lifestyle change(s) |
|---|---|---|---|
| 1. | Obesity | | Eating a balanced diet and exercising regularly |
| 2. | Diabetes | • Frequent urination<br>• Excessive thirst<br>• Weight loss<br>• Tiredness<br>• Slow healing | |
| 3. | High blood pressure | | |
| 4. | ........................... | ........................... | ........................... |

**Be a scientist**

Dr. Kamal Ranadive (1917–2001) was a pioneering biomedical researcher. She studied how hormones and certain viruses are linked to cancer, helping improve its treatment and prevention. Her work also showed how tobacco, diet, and pollution can raise the risk of cancer, highlighting the importance of a healthy lifestyle.

## 3.5 How to Prevent and Control Diseases?

You might have heard the phrase 'Prevention is better than cure.' It is important to protect ourselves from both communicable and non-communicable diseases.

### Activity 3.6: Let us read

#### Odisha — community-led sanitation campaign

In Bhadrak district, Odisha, a community sanitation campaign helped more people build and use toilets. This reduced open defecation significantly, and improved child health, with fewer cases of diarrhoea and infections.

What do you **infer** from this case study? Simple steps like good sanitation can greatly reduce the spread of communicable diseases. Find about such community campaigns held in your location. Share in your class and discuss with your peers about the impact of such initiatives.

#### Ability of the body to fight diseases

You would have noticed that some people get sick more frequently than others, although living in a similar environment. Do you know why? The natural ability of our body to fight diseases is known as **immunity**. Our body has a special system called the immune system that helps fight against diseases.

You might have taken some drops or injections in your childhood to protect yourself from certain diseases, such as polio, measles, tetanus, and hepatitis. These are **vaccines** that help prevent serious infections caused by viruses and bacteria.

A vaccine helps our body fight certain diseases by training the immune system to recognise and attack harmful germs. providing what is known as **acquired immunity**—protection developed after exposure to a pathogen or a vaccine. Vaccines can be made in different ways—from weakened or dead pathogens (like viruses or bacteria), or from inactive or harmless parts of the pathogen. Some newer vaccines instruct our own body cells to make a harmless part of the germ, which our immune system then learns to fight.

For example, a tetanus shot, often given after an injury protects against infection by the tetanus-causing bacteria. It contains an inactivated bacterial toxin that helps the immune system develop protection without causing the disease.

Do you know when the first vaccine was discovered?

## Edward Jenner and the smallpox vaccine

Smallpox was a deadly disease that caused blisters and killed millions. A milder disease called cowpox, seen in cows, could also infect humans. In the late 1700s, English doctor Edward Jenner discovered that people who had cowpox did not get smallpox. This led to the invention of the first vaccine and helped protect people from smallpox.

### Our scientific heritage

Long before modern vaccines, India had a traditional method called variolation to protect against smallpox. It involved using material from a smallpox sore to scratch the skin and create a mild infection and build immunity. People who performed this practice were known as *teekedaars*.

### Think like a scientist

**Observations**

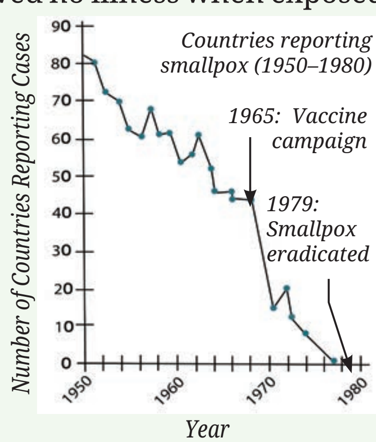
Jenner observed that milkmaids who had cowpox did not catch smallpox, likely because the two viruses are related.

**Hypothesis**

Content in the pus of cowpox blisters protected people from smallpox.

**Experimentation**

He tested this by injecting cowpox sap into a boy, who later showed no illness when exposed to smallpox.




**Results**

He found that people who were infected with cowpox sap were now resistant to smallpox.

**Application**

Mass vaccination eventually helped eradicate smallpox worldwide.

Vaccines are one of the most effective ways to protect people of all ages—from infants to the elderly—against many serious diseases. They help prevent illnesses, reduce the spread of infections, and save millions of lives every year. It is important to remember that vaccines are preventive, not curative—they can help minimise serious diseases before they happen, but do not treat them once someone is already sick. Some people may fear or doubt vaccines, but scientists and doctors carefully test them for safety. Getting vaccinated not only protects you but also the people around you.

### Ever heard of ...


**India's Role in Vaccine Production**
India is one of the world's largest vaccine producers. It manufactures vaccines on a massive scale and supplies them to many countries. Indian vaccine companies played a key role during the COVID-19 pandemic and continue to support global health efforts.

### Be a scientist

Dr. Maharaj Kishan Bhan was a well-known Indian doctor and scientist. As Secretary of the Department of Biotechnology, he helped promote science and innovation in India. He played a key role in developing the Rotavirus vaccine, which protects children from diarrhoea. He believed in using research to create affordable healthcare and made a big difference in India's health and biotechnology sectors.

## 3.5.1 Treatment of diseases

If our immune system fails to protect us against an infectious disease, we fall ill and need to visit a doctor. The doctor may give us medicines called **antibiotics**, which kill the bacteria that might have caused the disease. Antibiotics work only against bacterial infections because they target parts of bacterial cells that are different from human or other animal cells. They do not work against viruses or diseases caused by protozoa.

## Think like a scientist

**Discovery of the first antibiotic, Penicillin**

Penicillin was discovered in 1928 by Alexander Fleming, a bacteriologist from London. While studying harmful bacteria, he noticed that a mould on a discarded petri dish stopped the bacteria from growing. He realized the mould released a substance that killed the bacteria. This chance discovery led to the discovery of penicillin, the first antibiotic used to treat bacterial infections.

Though antibiotics are effective in protecting us against bacterial infections and have saved millions of lives since their discovery, their indiscriminate use has led to a decline in their effectiveness (Fig. 3.5a). Nowadays, there are news headlines about **antibiotic resistance**, a phenomenon where bacteria that were earlier killed by a given antibiotic are found to survive and multiply despite treatment with that antibiotic. This makes

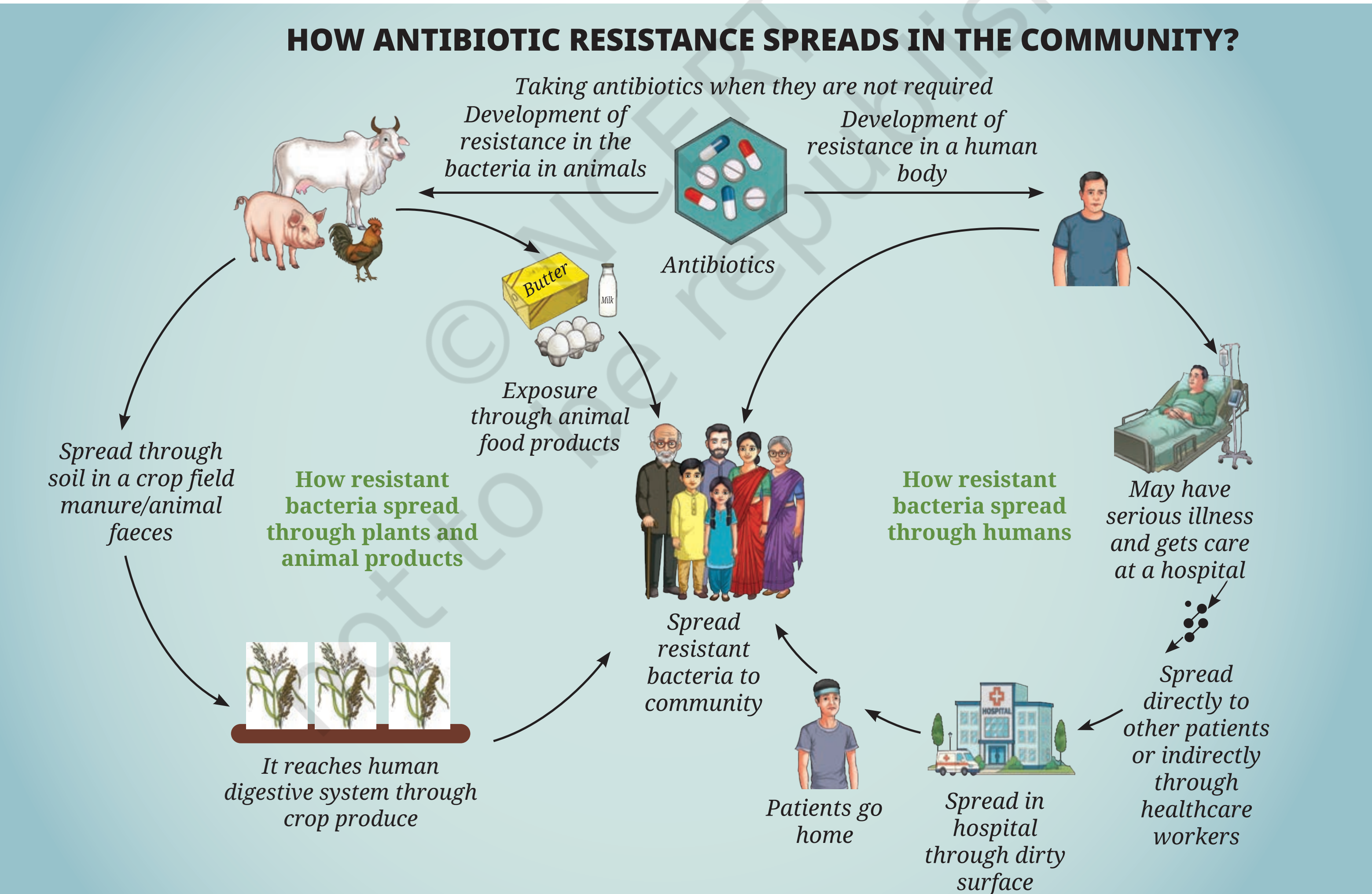



Fig. 3.5 (a): Spread of antibiotic-resistant bacteria in community

common infections harder to treat and increases the risk of complications, prolonged illness, and even death.

## Activity 3.7: Let us infer

- Study the infographic given in Fig. 3.5b. How do you think the antibiotic resistance has been developed in bacterial pathogens? What precautions may be taken to reduce antibiotic resistance?
- To tackle the problem of antibiotic resistance, we must use antibiotics wisely—only when prescribed by a doctor, in the correct dose, and for the right duration. Avoiding unnecessary use helps prevent the rise of resistant bacteria and keeps antibiotics effective for future generations.

Traditional medicine systems like Ayurveda, Siddha, and Unani have been used in India for many years to manage common health problems. They use natural substances like herbs, oils,

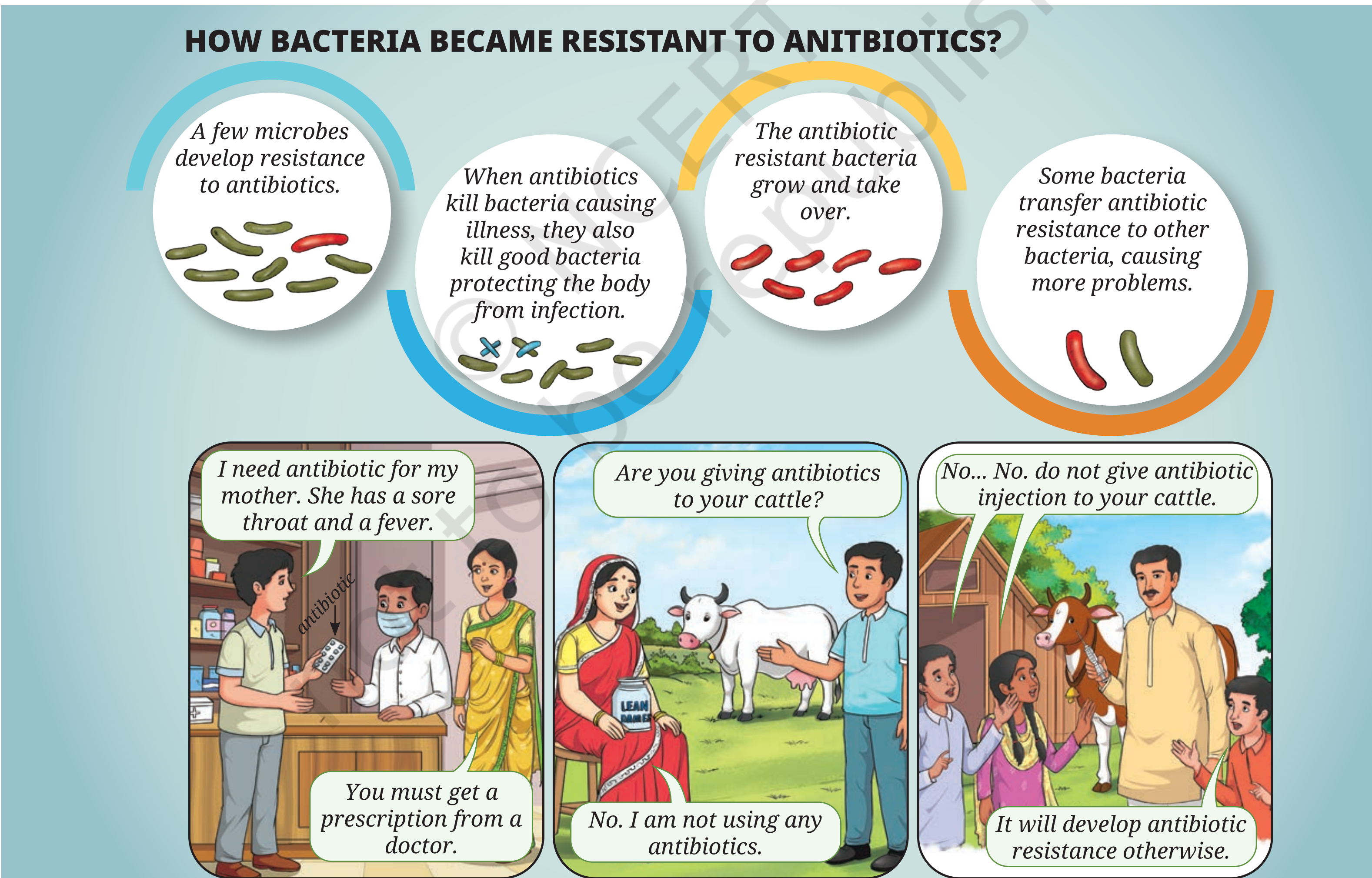



*Fig. 3.5 (b): Development of antibiotic-resistant bacteria and preventive measures*

and minerals for managing illnesses and promoting recovery, and focus on a healthy lifestyle and balanced diet. While these systems can help with some conditions, and are useful for everyday well-being, they may not be effective for all diseases and at all stages.

Therapies for non-communicable diseases focus on managing symptoms and improving quality of life through medication, lifestyle changes, and rehabilitation. Early diagnosis and continuous care are key to control the disease progression and prevent complications.

## Snapshots

- Health means complete physical, mental, and social well-being—not just the absence of disease.
- Being happy helps us stay active and healthy, and good health also improves our mood. Health and happiness are closely related.
- A disease affects the normal working of the body or mind.
- Symptoms are what we feel (like pain or tiredness); signs are what can be seen or measured (like fever or rash).
- Non-communicable diseases like diabetes and heart disease are caused by lifestyle and environmental factors, not germs. They can often be prevented with healthy habits, lifestyle changes, and regular exercise.
- Infectious diseases are caused by pathogens like bacteria, viruses, or worms.
- Our immune system helps protect us from harmful pathogens.
- Vaccines train the immune system using dead, weakened, or harmless parts of a germ to prevent disease.
- Diagnosis and treatment are important for managing and curing diseases.



## Keep the curiosity alive

1. Group the diseases shown in the images as communicable or non-communicable.

*Cold and flu*

*Typhoid*

*Diabetes*

*Asthma*

*Chickenpox*

2. Diseases can be broadly grouped into communicable and non-communicable diseases. From the options given below, identify the non-communicable diseases.

   (i) Typhoid (ii) Asthma (iii) Diabetes (iv) Measles

   (a) (i) and (ii) (b) (ii) and (iii) (c) (i) and (iv) (d) (ii) and (iv)

3. There is a flu outbreak in your school. Several classmates are absent, while some are still coming to school coughing and sneezing.
   (i) What immediate actions should the school take to prevent further spread?
   (ii) If your classmate, who shares the bench with you, starts showing symptoms of the flu, how can you respond in a considerate way without being rude or hurtful?
   (iii) How can you protect yourself and others from getting infected in this situation?

4. Your family is planning to travel to another city where malaria is prevalent.
   (i) What precautions should you take before, during, and after the trip?
   (ii) How can you explain the importance of mosquito nets or repellents to your sibling?
   (iii) What could happen if travellers ignore health advisories in such areas?

5. Your uncle has started smoking just to fit in with his friends, even though it is well known that smoking can seriously harm health and even cause death.
   (i) What would you say to him to make him stop, without being rude?
   (ii) What would you do if your friend offers you a cigarette at a party?
   (iii) How can schools help prevent students from indulging in such harmful habits?

6. Saniya claims to her friend Vinita that "Antibiotics can cure any infection, so we don't need to worry about diseases." What question(s) can Vinita ask her to help Saniya understand that her statement is incorrect?

7. The following table contains information about the number of dengue cases reported in a hospital over a period of one year:

| S. No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | January | February | March | April | May | June | July | August | September | October | November | December |
| No. of dengue cases | 10 | 12 | 15 | 18 | 22 | 40 | 65 | 65 | 65 | 30 | 30 | 20 |

Make a bar graph of the number of cases on the Y-axis and the month on the X-axis. Critically analyse your findings and answer the following:

(i) In which three months were the dengue cases highest?

(ii) In which month(s) were the cases lowest?

(iii) What natural or environmental factors during the peak months might contribute to the increase in dengue cases?

(iv) Suggest a few preventive steps that the community or government can take before the peak season to reduce the spread of dengue.

8. Imagine you are in charge of a school health campaign. What key messages would you use to reduce communicable and non-communicable diseases?

9. It is recommended that we should not take an antibiotic for a viral infection like a cold, a cough, or flu. Can you provide the possible reason for this recommendation?

10. Which disease(s) among the following may spread if drinking water gets contaminated by the excreta from an infected person?
Hepatitis A, Tuberculosis, Poliomyelitis, Cholera, Chickenpox.




**Prepare some questions based on your learnings so far ...**

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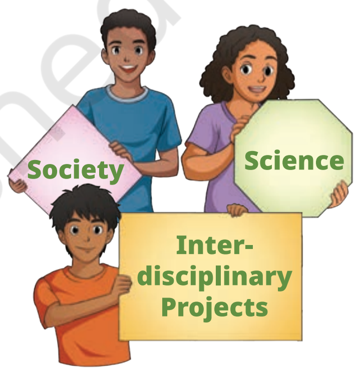
11. When our body encounters a pathogen for the first time, the immune response is generally low but on exposure to the same pathogen again, the immune response by the body is much more compared to the first exposure. Why is it so?

## Discover, design, and debate

- Students maintain a health diary for at least a month to track food, hygiene, exercise, sleep, screen time, and emotional state.
- Read about Indian scientists like Suniti Solomon, Asima Chatterjee, Dr. Yellapragada Subbarao, Dr. Mary Poonen Lukose for their contributions in the field of health and diseases.
- The deadly disease smallpox was eradicated by vaccination. Discover how this was done and why it worked. Debate whether everyone should be required to get vaccinated to protect others.
- According to current guidelines, learn the correct sequence of steps for performing cardiopulmonary resuscitation (CPR) on an adult in case of sudden stoppage of breathing. School may invite a doctor or a professional to demonstrate a mock drill.
- Invite a doctor to the school. Students may be encouraged to interact with the doctor on the issues of malnutrition, under-nutrition, and over-nutrition.
- If you are given an opportunity to create a health card, what all would you like to include in it. Create your own health card and have discussion about it.
- Have a debate on 'Are there ill-effects of fast food on companion animals?






**Reflect on the questions framed by your friends and try to answer ...**

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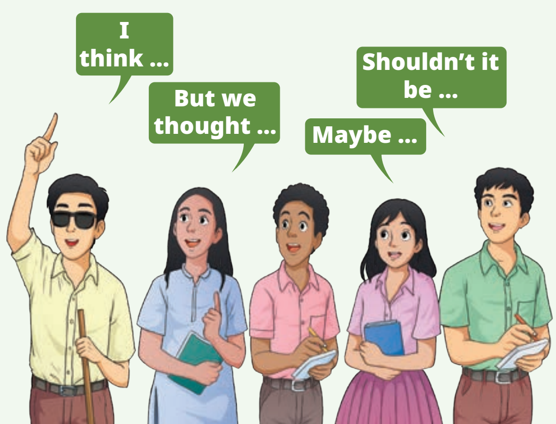


# 4 Electricity: Magnetic and Heating Effects

0877CH04

## Probe and ponder

- If we don't have an electric lamp while making an electric circuit with an electric cell, is there any other way through which we can find out if current is flowing in the circuit?
- Is it possible to make temporary magnets? How can these be made?
- We can generate heat by burning fossil fuels and wood; but how is heat generated in various electrical appliances?
- How do we know if a cell or a battery is dead? Can all cells and batteries be recharged?
- Share your questions

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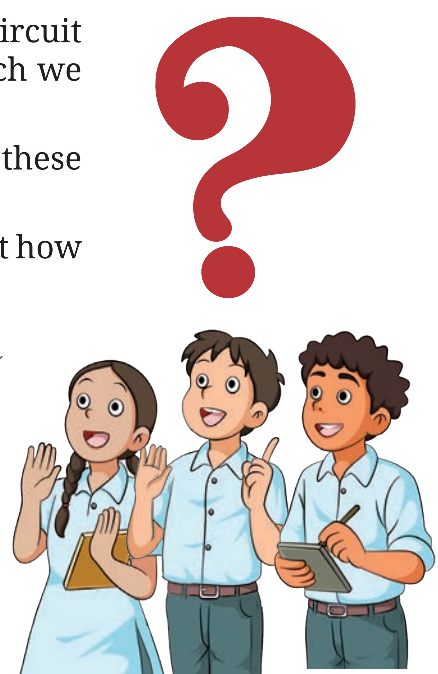
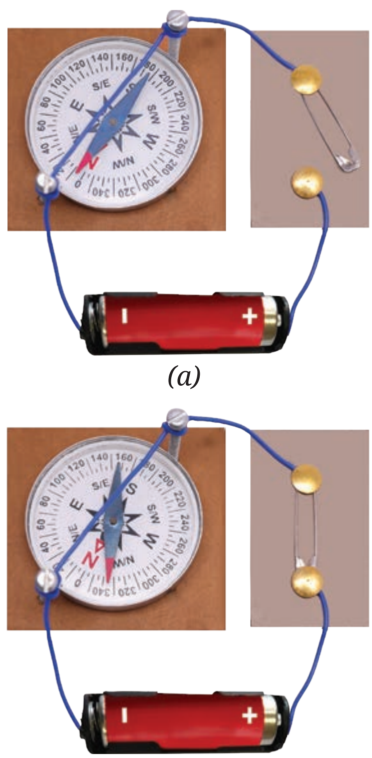


It was the day of the science exhibition, and the school was buzzing with energy. Mohini and Aakarsh, along with their friends, went from one exhibit to another, eagerly exploring different models, asking questions and taking notes. One simple model really fascinated them. It was a working model of a lifting electromagnet which was displayed by their senior, Sumana. In it, instead of a hook like a typical crane, there was an iron nail wrapped with a wire, which was connected to a battery. When Sumana closed the circuit, the nail picked up iron paper clips like a magnet. When she opened the circuit, the clips fell off. Mohini and Aakarsh, were surprised. They remembered learning earlier (in the chapter 'Exploring Magnets', *Curiosity*, Grade 6) that magnetic materials were attracted by magnet and that iron was a magnetic material. But in Sumana's model, there was no magnet, only an electric circuit. They were so excited that they wanted to try it out themselves.

## 4.1 Does an Electric Current Have a Magnetic Effect?

### Activity 4.1: Let us investigate

- Collect a magnetic compass, an electric cell, a cell holder, two drawing pins, a safety pin, two nails, two pieces of connecting wires (one longer and one shorter), and two small pieces of cardboard.
- Using two drawing pins, a safety pin, and a cardboard piece, make a switch (as you made it earlier in the chapter 'Electricity: Circuits and their Components' in *Curiosity*, Grade 7).
- Place the cell in the cell holder.
- Fix two nails to a piece of cardboard as shown in Fig. 4.1a. Fix the middle portion of the longer wire stretched between the nails, such that it is slightly above the surface of the cardboard. Attach one end of that wire to the cell holder and another end to the switch.
- Connect the second wire between the cell holder and the switch.
- Place the magnetic compass beneath the wire between the two nails (Fig. 4.1a).



(a) (b)

*Fig. 4.1: An electric circuit and a magnetic compass*

While watching the compass needle, move the switch to 'ON' position to allow electric current to flow through the wire (Fig. 4.1b). What do you **observe**?

- Now again while watching the compass needle, move the switch to 'OFF' position. What do you observe this time?
- Move the switch between 'ON' and 'OFF' positions a few more times. Carefully observe how the compass needle behaves the each time.

You may have **noticed** that when the current flows, the compass needle gets deflected from its original direction. When the current stops, the needle returns to its original direction.

As we have learnt earlier (in the chapter 'Exploring Magnets' in *Curiosity*, Grade 6), the compass needle is a tiny magnet which deflects when a magnet is brought near it and this magnetic effect can act through any non-magnetic materials kept in between. But why does the compass needle deflect when the current flows through the wire? The deflection indicates that the current carrying wire has a magnetic effect on the compass needle. When the current stops, this magnetic effect disappears and the compass needle returns to its original direction. The region around a magnet or a current carrying wire where its magnetic effect can be felt, such as by the deflection of a compass needle, is said to have a **magnetic field**.


When electric current flows through a conductor (like a wire), it produces a magnetic field around it. This phenomenon is known as the **magnetic effect of electric current**. The magnetic field disappears when the current stops flowing.

## Be a scientist

You have just now made the same discovery which was made by the scientist Hans Christian Oersted (1777–1851) in 1820, that is, the discovery that electricity and magnetism are linked. He was a professor at a university in Denmark. It is said that once while giving a demonstration, he noticed that whenever an electrical circuit was closed or opened, the needle of a magnetic compass, lying nearby, deflected. He investigated this and when he was certain that an electric current indeed produced a magnetic field, he published his findings. This led to other scientists repeating his experiment to check if they got the same results, and further investigating the connection between electricity and magnetism.

The magnetic effect of electric current has many practical applications, such as in devices like electromagnets, electric bells, motors, fans, loudspeakers, and more.


### 4.1.1 Electromagnets

## Activity 4.2: Let us explore

- Take around 50 cm long length of a flexible insulated wire, an iron nail, an electric cell, and few iron paper clips.
- Tightly wrap the wire around the nail in the form of a coil, as shown in Fig. 4.2, and secure it with an adhesive tape.
- Connect the ends of the wire to the cell. Take care to not connect the wires to the cell for more than a few seconds; otherwise, the cell may weaken quickly.
- Bring the nail close to the iron paper clips and lift up. Do the clips hang to the ends of the nail?
- Disconnect the wire from the cell to stop the flow of electric current in the wire. Do the clips fall down?

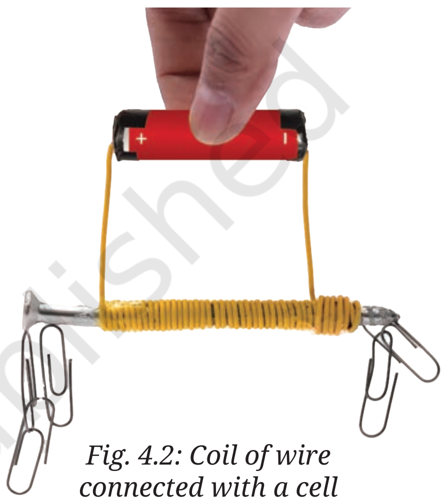


*Fig. 4.2: Coil of wire connected with a cell*

When electric current flows through the coil, the clips cling to it. But when the current is stopped, the clips no longer cling to it. Let us now try to **investigate** these observations in detail through Activity 4.3.

## Activity 4.3: Let us experiment

- Take around 100 cm long flexible insulated wire, a piece of chart paper, an iron nail, an electric cell, two magnetic compasses, and few iron/steel paper clips.
- Roll a piece of chart paper to make a cylinder of diameter roughly equal to the width of a pencil. Secure it with an adhesive tape.
- Tightly wind around 50 turns of the insulated wire on the cylinder to form a cylindrical coil as shown in Fig. 4.3a. Secure the wire with an adhesive tape.

*Fig. 4.3: (a) A coil of insulated wire*

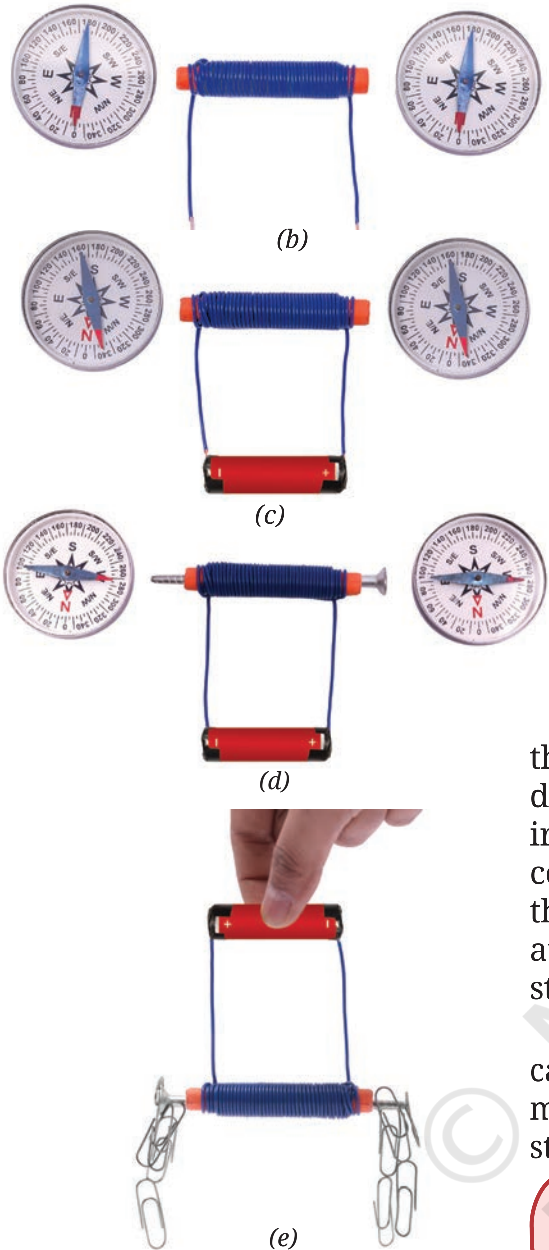



Fig. 4.3: (b) Coil and magnetic compasses; (c) Coil connected to a cell; (d) Coil with iron nail inserted; (e) Coil with iron nail and clips

- Place the compasses near the two ends of the cylindrical coil (Fig. 4.3b).
- Connect the two ends of the coil with the terminals of the cell as shown in Fig. 4.3c and observe the magnetic compasses. Do you find any deflection in the needles of the compasses?
- Disconnect the wire from the cell. Do the needles of the compasses come back to their original positions?
- Insert an iron nail in the paper cylinder (Fig. 4.3d) and repeat the steps. Is there any difference in the deflection of the compass needles?
- Place some iron paper clips near the two ends of the nail. Are the clips attracted to the ends of the nail?

It is observed that when current is passed through the cylindrical coil, it behaves like a magnet and deflects the needle of a magnetic compass. When an iron nail is inserted in the core of the coil, then the coil becomes a stronger magnet and the deflection of the magnetic compass needle is much more. It also attracts iron clips (Fig. 4.3e). When the current is stopped, the cylindrical coil loses its magnetic effect.

A current carrying coil that behaves as a magnet is called an **electromagnet**. For practical applications, most electromagnets have an iron core to make them stronger.

Does electromagnet also have two poles like a bar magnet?

## Activity 4.4: Let us investigate

- Take the electromagnet made in Activity 4.3 and a magnetic compass. Label the two ends of the coil as A and B.
- Place the magnetic compass near the end A of the coil as shown in Fig. 4.4a.
- Connect the coil to the cell and observe the compass. Note down which pole of the magnetic compass is attracted to end A.

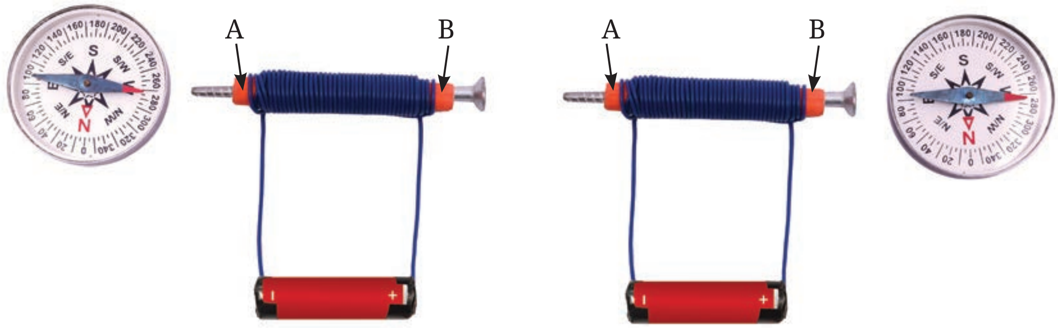



*Fig. 4.4: Compass needle near (a) End A; (b) End B of an electromagnet*

As we have learnt earlier, when two magnets are brought close to each other, their unlike poles (North–South) attract each other. So, if north pole of the magnetic compass is attracted towards end A of the electromagnet, then end A is south pole.

- Repeat this procedure to find the polarity of end B as well (Fig. 4.4b). Did you find that the polarity of end B is opposite to the polarity of end A?

We learnt in grade 6 that a magnet has two poles. Just like a magnet, an electromagnet also has two poles—North and South.

## Think like a scientist

Repeat Activity 4.3 with— (i) 2 and 4 cells with the same coil, (ii) 2 cells but different number of turns of the coil. What do you observe?

A single cell provides only a small amount of current, so the magnetic field is weak. As a result, the deflection of compass needle is less and the coil can only attract a few clips. A battery with more cells gives a larger current as compared to that with a single cell. This creates a stronger magnetic field, so the deflection of the compass needle is more and the coil can attract more clips. The increase in number of turns of the coil also makes the coil a stronger magnet!

Also, repeat Activity 4.4 by changing the direction of the current. So, the strength of an electromagnet can be changed by changing the amount of electric current flowing through the coil or the number of turns of the coil, or both. Also, its poles can be reversed by changing the direction of the current.

## A step further

Do you remember learning earlier (in the chapter 'Exploring Magnets' in *Curiosity*, Grade 6) that a freely suspended magnet rests along the north–south direction because our Earth itself behaves like a giant magnet? But why does Earth behave like a magnet? Deep inside the Earth, the movement of liquid iron in the core creates electric currents, which generate a magnetic field. Many migratory birds, fish, and animals use this field to navigate across continents and oceans. The Earth's magnetic field also acts as a shield, blocking harmful particles from space, and helps protect life on Earth.


### 4.1.2 Lifting electromagnets

Lifting electromagnets are strong electromagnets, that may be hung to the cranes. The crane operator can control the magnet by switching the current ON and OFF. When the current is turned ON, the electromagnet lifts the iron/steel objects; when the current is switched OFF, magnetic field disappears, and the objects are released. Lifting electromagnets are widely used in factories and scrap yards, to move, lift, and sort heavy metal items efficiently.

**A step further**

We have learnt that when electric current flows through a conductor (like a wire), it produces a magnetic field around it. In the higher grades, you will learn even more about this wonderful link between electricity and magnetism, including the exciting idea that just as electricity can produce magnetism, a moving magnet can also lead to an electric current. This deep connection between electricity and magnetism is vital to our daily lives, as it forms the basis of many devices, from electric motors to power generators.

## 4.2 Does a Current Carrying Wire Get Hot?

### Activity 4.5: Let us observe


In this activity, we will use a special kind of wire, called a nichrome wire.

- Take a cardboard piece of about 10 cm length and 10 cm width, two nails, a nichrome wire of thickness about 0.3 mm (26–28 gauge) and length of 10 cm, an electric cell, a cell holder, a switch, and connecting wires.
- Mount the nails on the cardboard about 5 cm apart.
- Tie the nichrome wire between these nails and make the connections as shown in Fig. 4.5 with the switch in OFF position.
- Touch the nichrome wire. What do you feel?
- Move the switch to ON position for about 30 s and then move it back to OFF. Touch the nichrome wire momentarily

(Do not hold the nichrome wire). What difference do you feel?

- Repeat the last two steps to **confirm** the observation.

**Safety first**

Do not touch the wire for an extended period to avoid any injuries.

You may have observed that nichrome wire feels warm when current is passed through it. This happens because, when electric current flows through any conductor, it faces some opposition or resistance to its flow. Different conductors offer different levels of resistance to the flow of current. A nichrome wire, for example, offers higher resistance compared to a copper wire of the same size and length. This resistance causes some of the electrical energy to be converted into heat energy. When an electric current passes through a conductor, it gets heated. This warming is known as the **heating effect of electric current**.

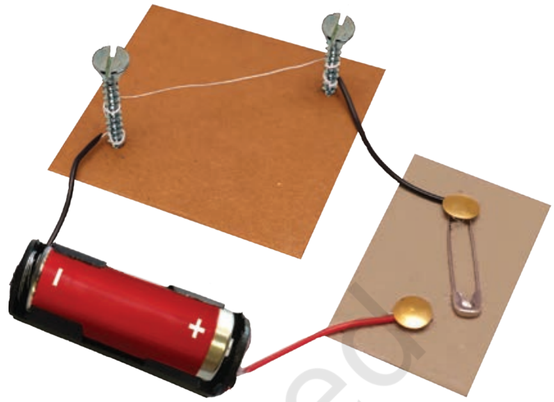



*Fig. 4.5: Heating effect in a wire*

## Think like a scientist

This activity should be carried out strictly under the supervision of a teacher.

Repeat Activity 4.5 with a battery of 2 cells. What do you notice? For the same duration, does the wire heat up more with one cell or two cells?

The amount of heat generated is more in the experiment with 2 cells. This is due to the fact that the heat generated depends on the magnitude of the electric current. The heat generated in a wire depends on the material, thickness, and length of the wire, and the duration for which the current flows.

In Grade 7, we have learnt that an incandescent lamp glows because its filament is heated by an electric current. Many household appliances, such as electric room heaters, stoves, irons, immersion rods, water heaters, kettles, and hair dryers (Fig. 4.6) work on the same principle of the heating effect of electric current. All these devices contain a rod or a coil of wire, called a heating element. In some appliances where this element is visible, it can be seen glowing red hot.

Oh, now I understand why the incandescent torch lamp sometimes used to get warm when we did the activity of making it glow using an electric cell.


*Fig. 4.6: Simple household electric heating appliances (a) Room heater; (b) Electric stove; (c) Electric kettle; (d) Electric iron; (e) Water heating immersion coil; or (f) Hair dryer*

The heating effect of electric current is useful in many everyday appliances. But sometimes, it can cause problems, like energy loss in wires during transmission. Overheating in appliances may cause damage to plugs and sockets where plastic parts may melt, or even lead to fires. In household circuits, there are safety devices placed in the circuit to minimise such incidents.

## A step further

To prevent unnecessary heating in household switchboards, it is important to use appropriate wires, plugs, and sockets that are rated for the specified electric current of the connections.

## Ever heard of ...

Beyond household use, heating effect of electric current has several industrial applications. One notable example is in steel manufacturing industries, where a specially designed high-temperature furnace (an enclosed space built to generate heat) uses electric current to produce heat. This is used to melt and recycle scrap steel, converting it into usable steel.

The portable sources of electricity, such as cells and batteries, are so fascinating. Using these, we could light up a small lamp, make a magnet, and heat up a wire.

Yes, but have you ever wondered what is inside these cells and batteries that produces electricity?

## 4.3 How Does a Battery Generate Electricity?

Let us start with one of the earliest types of electric cells ever made.

### 4.3.1 Voltaic cell

A Voltaic cell, also known as Galvanic cell, is shown in Fig. 4.7. It contains two metal plates made of different materials and a liquid called an electrolyte, placed in a glass or plastic container. The plates, called electrodes, are partly dipped in the electrolyte, which is usually a weak acid or salt solution. A chemical reaction between the plates and the electrolyte produces electricity. When the circuit is connected, electric current flows from the positive terminal through the circuit to the negative terminal. Over time, the chemicals get used up, and the cell stops working. It is then called 'dead' and cannot supply any more electricity.

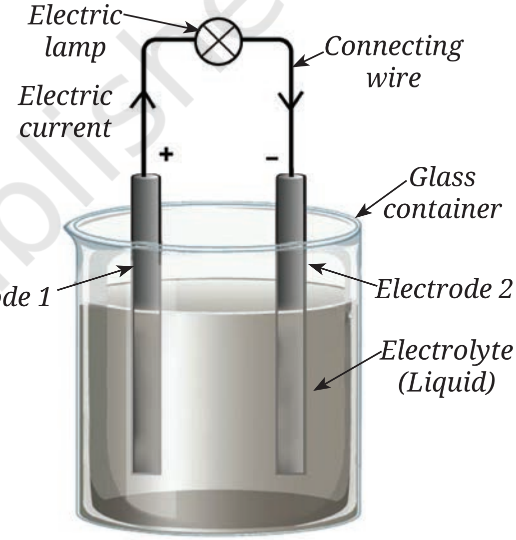
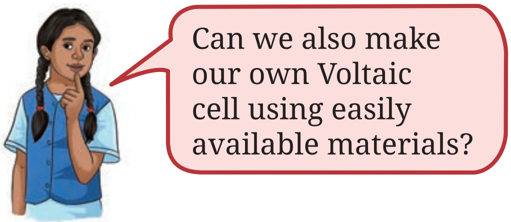



*Fig. 4.7: Simple representation of a Voltaic cell*

**Ever heard of ...**

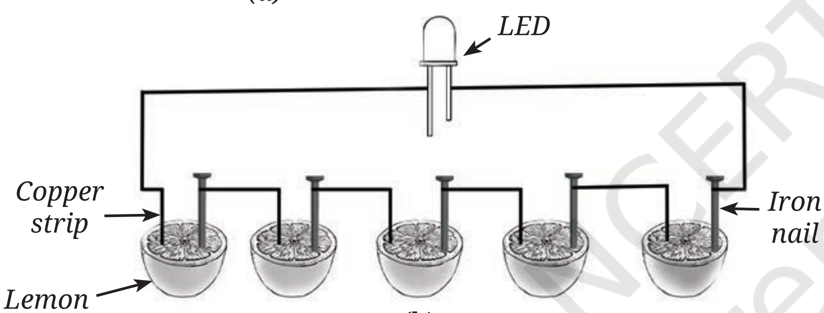
The Voltaic or Galvanic cells get their names from two Italian scientists, Alessandro Volta and Luigi Galvani. In the late 1700s, Galvani noticed that a dead frog's leg kicked when touched with two different metals—copper and iron. It was already known by then that electricity could stimulate muscular motion and Galvani thought the electricity came from the frog itself. But Volta had a different idea. He believed the electricity came from the metals, and not the frog. To test this, he used saltwater-soaked paper instead of the frog's leg and still got an electric current. This showed that it was the combination of metals and liquid that generated electric current—leading to the invention of the first battery!

## Activity 4.6: Let us construct




- Take five or six juicy lemons, copper wires/strips (1–2 mm thick) and iron nails. Also take one LED and some connecting wires.
- Insert the copper wire and the iron nail in one of the lemons keeping them apart by a small distance as shown in Fig. 4.8a.
- Repeat the above step for all the remaining lemons.
- Join the copper wires and nails as shown in Fig. 4.8b.
- Connect the LED between the copper wire of the first lemon and the iron nail of the last lemon, using connecting wires. What do you observe? Does the LED glow?
- If the LED does not glow, reverse its connections. Does the LED glow now? [Remember that we have learnt earlier that current can pass through the LED only when the positive terminal (longer wire) of the LED is connected to the positive terminal of the battery, and negative terminal (shorter wire) of the LED is connected to the negative terminal of the battery].

*(a)*




*(b)*

*Fig. 4.8: (a) Electric cell made using lemons; (b) Connections in lemon cell*

A glowing LED indicates that your cell is working. In this cell, the metal electrodes are the copper wires and the iron nails. The electrolyte is the lemon juice, which helps conduct electricity. You may also use salt solutions instead of lemon juice.

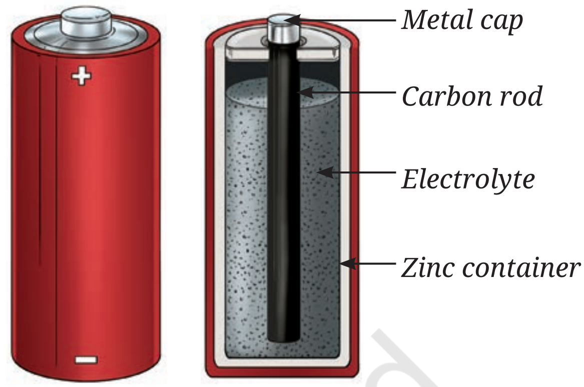
### A step further

Some common metal pairs for Voltaic cells are zinc/copper, zinc/silver, aluminium/copper, iron/copper, magnesium/copper, and lead/copper. Some metals—like copper—act as positive electrodes, yet some other metals—like zinc—act as negative electrodes. This is due to their chemical properties. We will learn more about this in the higher grades.

### 4.3.2 Dry cells

Voltaic cells were an important discovery, but they are not convenient for everyday use. Instead, dry cells are one of the most widely used electric cells today. They are called 'dry' because the electrolyte is not a liquid but a thick moist paste. The structure of a dry cell is shown in Fig. 4.9. It consists of a zinc container which acts as a negative terminal and a carbon rod at the centre covered with metal cap that acts as the positive terminal. The carbon rod is surrounded by the paste-like electrolyte.

The dry cell is a single use cell, meaning once it is used up, it has to be disposed of. For several applications, rechargeable batteries are increasingly being used now.

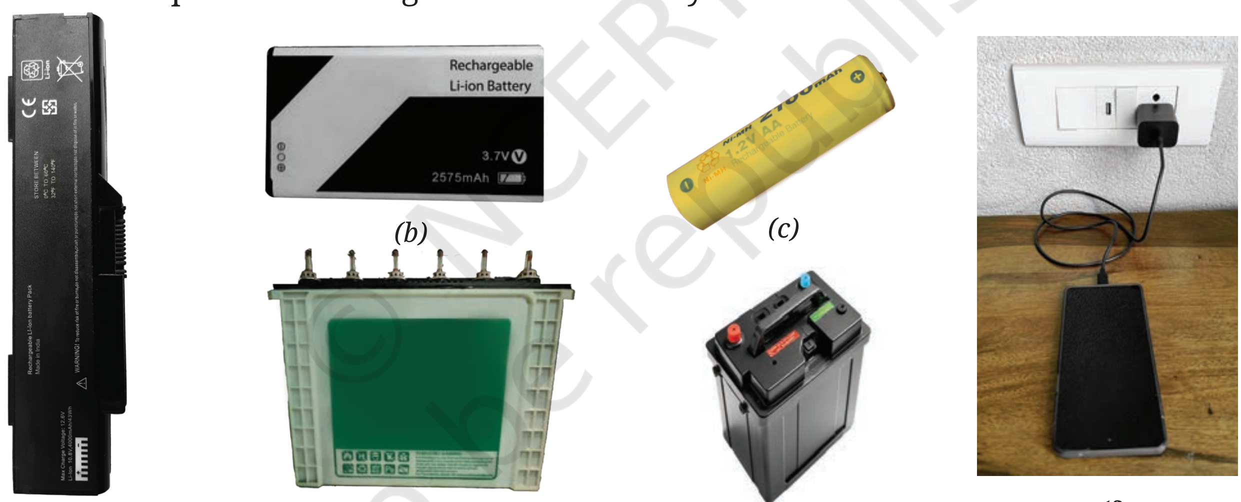



*(a)* *(b)*

*Fig. 4.9: (a) Dry cell; (b) Its internal structure*

### 4.3.3 Rechargeable batteries

Rechargeable batteries can be recharged and reused multiple times. This prevents wastage and saves money over time as well.




*(a)* *(b)* *(c)* *(d)* *(e)* *(f)*

*Fig. 4.10: Typical rechargeable batteries used in (a) Laptops; (b) Mobile phones; (c) Camera; (d) Inverter; (e) Vehicles; (f) Charging a mobile phone*

There are many different kinds of rechargeable batteries that are used for different applications—from small batteries used in watches and phones to batteries used in laptops and tablet to bigger batteries that run inverters or drive electric vehicles (Fig. 4.10). However, rechargeable batteries also do not last forever. After being charged and used many times, they slowly wear out.

Oh, so this is the reason why after a year or two, the phone battery requires charging more often!

## A step further

Today, the lithium-ion (Li-ion) battery is the most common type of rechargeable battery, found in almost all devices that use batteries. These batteries rely on special metals like lithium and cobalt, which are mined and processed in limited parts of the world. Because of this, countries are now racing to secure supplies, recycle old batteries, and develop new technologies.

Scientists are also working on the next big leap: solid-state batteries, which replace the liquid or paste-like electrolytes with solid materials. These future batteries would be much safer, charge faster and last longer. Improved rechargeable batteries are very important as the world moves to developing environmentally friendly sources of electrical power.

## Snapshots

- When electric current flows through a conductor (like a wire), it produces a magnetic field around it. This phenomenon is known as the magnetic effect of electric current.
- A current carrying coil that behaves as a magnet is called an electromagnet. For practical applications, most electromagnets have an iron core to make them stronger.
- Generation of heat in conductors due to flow of electric current is known as the heating effect of electric current.
- A cell or a battery is a device that generates electric current because of chemical reactions taking place inside it.
- Rechargeable batteries can be recharged and reused multiple times.



## Keep the curiosity alive

1. Fill in the blanks:
   (i) The solution used in a Voltaic cell is called ________.
   (ii) A current carrying coil behaves like a _______ .
2. Choose the correct option:
   (i) Dry cells are less portable compared to Voltaic cells. (True/False)
   (ii) A coil becomes an electromagnet only when electric current flows through it. (True/False)
   (iii) An electromagnet, using a single cell, attracts more iron paper clips than the same electromagnet with a battery of 2 cells. (True/False)

3. An electric current flows through a nichrome wire for a short time.
   (i) The wire becomes warm.
   (ii) A magnetic compass placed below the wire is deflected.
   Choose the correct option:
   (a) Only (i) is correct
   (b) Only (ii) is correct
   (c) Both (i) and (ii) are correct
   (d) Both (i) and (ii) are not correct

4. Match the items in Column A with those in Column B.

| Column A | | Column B | |
|---|---|---|---|
| (i) | Voltaic cell | (a) | Best suited for electric heater |
| (ii) | Electric iron | (b) | Works on magnetic effect of electric current |
| (iii) | Nichrome wire | (c) | Works on heating effect of electric current |
| (iv) | Electromagnet | (d) | Generates electricity by chemical reactions |

5. Nichrome wire is commonly used in electrical heating devices because it
   (i) is a good conductor of electricity.
   (ii) generates more heat for a given current.
   (iii) is cheaper than copper.
   (iv) is an insulator of electricity.

6. Electric heating devices (like an electric heater or a stove) are often considered more convenient than traditional heating methods (like burning firewood or charcoal). Give reason(s) to support this statement considering societal impact.

7. Look at the Fig. 4.4a. If the compass placed near the coil deflects: (i) Draw an arrow on the diagram to show the path of the electric current. (ii) Explain why the compass needle moves when current flows. (iii) Predict what would happen to the deflection if you reverse the battery terminals.



**Prepare some questions based on your learnings so far ...**

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8. Suppose Sumana forgets to move the switch of her lifting electromagnet model to OFF position (in introduction story). After some time, the iron nail no longer picks up the iron paper clips, but the wire wrapped around the iron nail is still warm. Why did the lifting electromagnet stop lifting the clips? Give possible reasons.

9. In Fig. 4.11, in which case the LED will glow when the switch is closed?

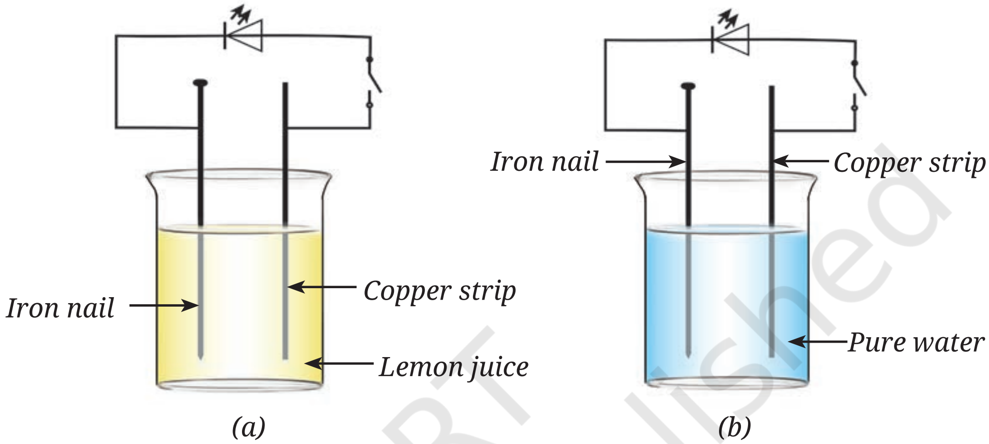



*Fig. 4.11*



10. Neha keeps the coil exactly the same as in Activity 4.4 but slides the iron nail out, leaving only the coiled wire. Will the coil still deflect the compass? If yes, will the deflection be more or less than before?

11. We have four coils, of similar shape and size, made up from iron, copper, aluminium, and nichrome as shown in Fig. 4.12.

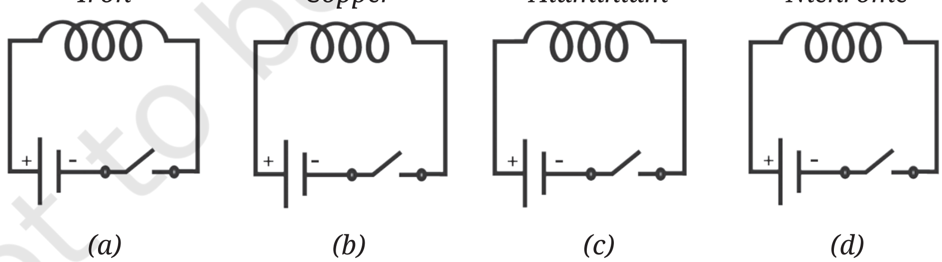
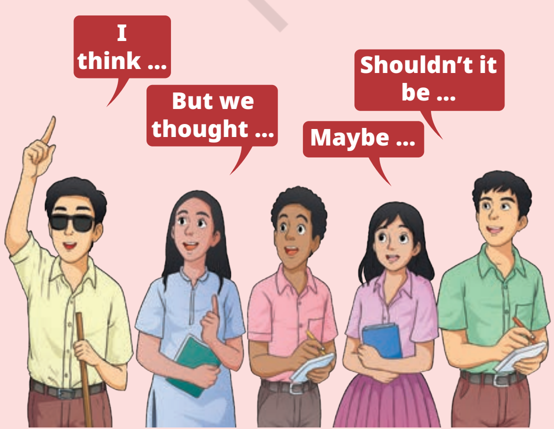



*Fig. 4.12*




**Reflect on the questions framed by your friends and try to answer ...**

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When current is passed through the coils, compass needles placed near the coils will show deflection.

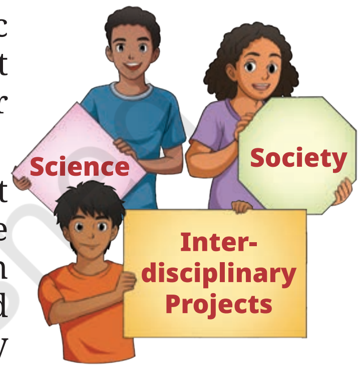
(i) Only in circuit (a)

(ii) Only in circuits (a) and (b)

(iii) Only in circuits (a), (b), and (c)

(iv) In all four circuits

## Discover, design, and debate




- Make coils of turns 25, 50, 75, and 100. Connect them to the same cell one by one. Note the deflection in a magnetic compass placed in the same position in all the cases. Report your observations. Draw conclusion of the effect of number of turns of the coil on the strength of the electromagnet.
- Take two thin nichrome wires of equal length and different thickness (approximately one of these wire thickness to be double of the other, say 0.3 mm and 0.6 mm). Connect them one by one in a circuit which has a switch and a cell, and allow the current to flow for 30 s in each case. Momentarily touch these wires. Which wire heats up more? Now repeat the same activity with two nichrome wires of same diameter but of different lengths. Prepare a brief report of your activity.
- Try to make an electric cell using various fruits and vegetables. Also try with electrodes of different metals. Prepare a brief report.

## A step further

Even when a battery stops working, it is not completely ‘dead’. It could still contain materials like acids, and metals like lead, cadmium, nickel, or lithium, which may cause fires, or be harmful for the environment if the battery is thrown in regular garbage. Further, many materials used in these batteries are valuable and could be recycled and reused. These days, there are many places with special ‘e-waste’ recycling facilities, where used batteries can be disposed of. If you are not sure, ask your teacher. Recycling batteries is good for the planet and the people.

# 5 Exploring Forces

## Probe and ponder

- Why does it feel harder to pedal a bicycle when going uphill than on flat ground?
- Why is it easier to slip on a wet surface?
- Why do we feel 'light' or like we are 'floating' just after our swing reaches its highest point and begins to come down?
- Share your questions

________________________________________

________________________________________ ?

It was a windy day. Sonali and Ragini were excited to go cycling. Their summer vacation had just begun, and they wanted to **explore** the beautiful landscapes around their village. After pumping air into their bicycle tyres, they set off. As they rode through the village, the wind rushed past them. "Oh no! The wind is pushing me hard!" said Ragini. Smiling, Sonali replied, "We are riding against the wind. We must push our pedals harder to move faster."

Their ride took them up a long path to a hilltop. Some parts of the road were rough where they found it hard to pedal, while other parts were smoother. When they reached the top and were enjoying the view, they heard thunder and saw flashes of lightning at a distance. Even though it looked beautiful, they decided to head back immediately. On the way back, while passing a herd of sheep, they pressed their bicycle bells and turned the handles to change direction.

As they were coming down the slope of the hill, they realised that their bicycles were moving down at a great speed even though they were not pedalling! Sonali yelled, "It's thrilling! It seems something is pulling us downhill, what could it be?"

## 5.1 What Is a Force?

Let us try to experience the push and the pull.

### Activity 5.1: Let us explore

- Take a large cardboard box.
- Try moving the box in as many different ways as you can think of.

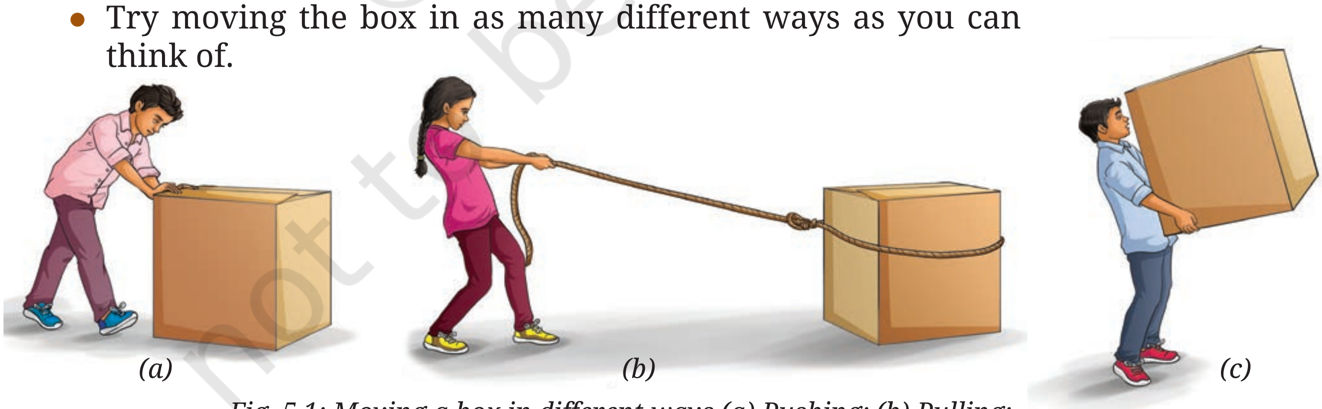



*Fig. 5.1: Moving a box in different ways (a) Pushing; (b) Pulling; (c) Lifting (pulling up), and carrying*

Did you move the box in any other way than shown in Fig. 5.1? In all the ways that you might have used to move the box, you had to apply a push or pull to the box. Generally, the push or pull applied on an object is called force in science.

## 5.2 What Can a Force Do to the Bodies on Which It Is Applied?

We experience push or pull in our daily lives all the time, often without even realising it. Let us recall some of these experiences and **analyse** them.

### Activity 5.2: Let us analyse

- **Think** of situations where a force (push or pull) is applied and list them in Table 5.1.
- Analyse each situation and write the effect of the force in Table 5.1. Some situations and their effects are already listed for you.

**Table 5.1: Different actions and their effects**

| S.No. | Action | Push/Pull | Effect |
|---|---|---|---|
| 1. | Your friend holding your moving bicycle from behind to stop it | Pull | Stopping or decreasing the speed of the bicycle |
| 2. | Hitting a moving ball with a bat | Push | Changing the direction of a moving ball |
| 3. | Pressing an inflated balloon | Push | Change in shape of the balloon |
| | ..................... | ..................... | ..................... |

What do you **conclude** from these examples? Does a force cause a moving object to stop? Can it change speed, or direction of motion, or change the shape of an object?

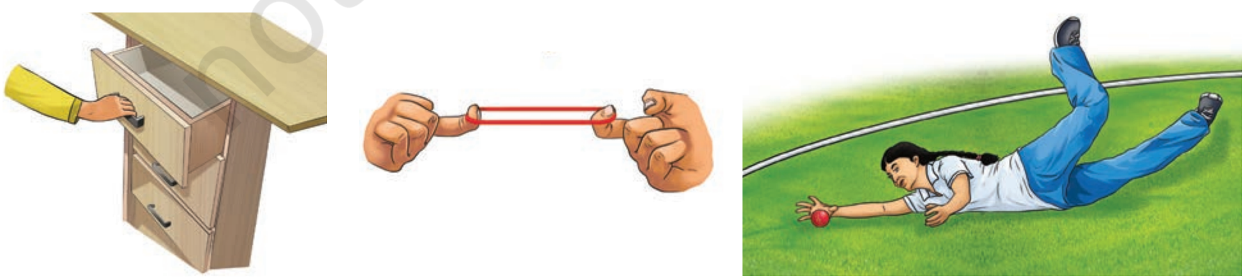


*Fig. 5.2: Applying force on objects*

In everyday life, we come across many situations where a force is applied, for example, opening a drawer, stretching a rubber band, a fielder stopping a ball, kicking a football, applying brakes on a moving bicycle, rolling a chapati, or turning the steering handle of an autorickshaw. What effect can the application of force have on objects?

The force applied on an object may

- make an object move from rest.
- change the speed of an object if it is moving.
- change the direction of motion of an object.
- bring about a change in the shape of an object.
- cause some or all of these effects.

Does this mean that whenever there is a change in speed or direction, or change in shape, a force is acting on the object?

Yes, none of these take place without the action of force.

**A step further**

Suppose an object is at rest. Does it mean that no force is acting on this object? It means that the forces acting on the object are balancing one another. You will learn about balanced forces in higher grades.

## 5.3 Are Forces an Interaction Between Two or More Objects?

When you push a table, your hand is one object applying force on another object—the table. Here, we say that your hand and the table are two objects interacting with each other.

Think of all the actions listed in Table 5.1. How many objects are involved in each of the actions? Do you **notice** that forces result only when two objects are interacting in some way or the other? From these examples, we can **infer** that at least two objects must interact for a force to come into play.

A **force** is a push or pull on an object resulting from the object's interaction with another object. The **SI unit of force is newton** (written with a small 'n') and its **symbol is N**.

## A step further

When you pushed the table with your hand, did you feel a force on your hand too? The moment you stopped pushing, the force on your hand disappeared. Whenever two objects interact, each object experiences a force from the other. As soon as the interaction ceases, the two objects no longer experience the force.

## 5.4 What Are the Different Types of Forces?

### 5.4.1 Contact forces

In many situations, we find that to apply a force on an object, physical contact is necessary between our body and the object. This contact can be direct, such as using our hands or other body parts, or indirect, such as using a stick or rope. Forces of this type which act only when there is physical contact between the objects are called **contact forces**.

### Muscular force

An example of contact force is muscular force. When we perform any physical activity, such as walking, running, lifting, pushing, jumping, or stretching, the force is caused by the action of muscles in our body. The force resulting due to the action of muscles is known as muscular force. **Muscular force** occurs when muscles contract and elongate while doing any activity.

Animals, birds, fish, and insects use muscular forces for movement and survival.

*Fig. 5.3: Use of muscular force by living beings*

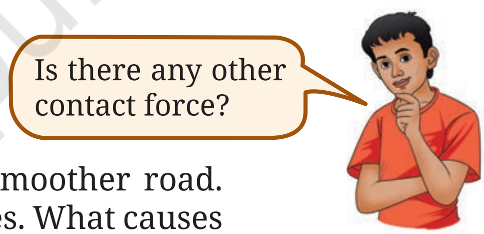
Humans used the muscular force of some animals to carry out many tasks for a long time.

*Fig. 5.4: Use of muscular force of animals to assist with human tasks*

## Ever heard of ...

Muscular force plays an important role in many functions inside our body too. This force helps us chew food and push it through the alimentary canal during the process of digestion. The expansion and contraction of our heart muscles allows the blood to circulate in our body—a process essential for survival.

## Friction




A ball rolling on a flat ground stops on its own after some time. If we stop pedalling our bicycle on a flat road, it slows down and comes to a stop. If the road is rough, it stops sooner than on a smoother road. You must have come across many such experiences. What causes the change in the speed of objects in such situations? We have learnt earlier that a force is essential to change the speed of an object. However, in all these situations no force appears to be acting on the objects, yet their speed gradually decreases and they come to a stop after some time. Is it possible that some force is indeed acting on them? Which force is that?

### Activity 5.3: Let us investigate

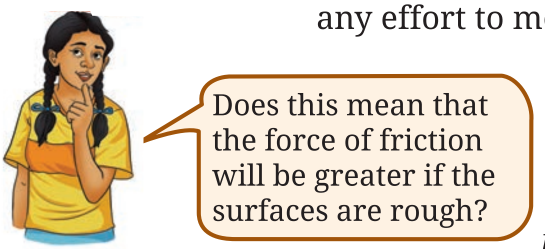
- Take an object with a flat base (such as an empty lunch box/ geometry box/ a notebook) and place it on a table or floor.
- Gently push it and **observe**. Does it stop after travelling some distance? Is there a force acting on it which brings it to rest?
- Now repeat by pushing the object in the opposite direction. Does it stop again after travelling some distance?

*Fig. 5.5: Friction acts between two surfaces and opposes the motion of the object.*

On pushing, the object stops after sliding a certain distance. This must be due to a force acting between the surfaces of the sliding object and the table or floor which are in contact. This force must be acting on the object in a direction opposite to its direction of motion. This force is what brings the object to a stop.

The force that comes into play when an object moves or tries to move over another surface is called the **force of friction** or simply **friction**. Friction always acts in a direction opposite to the direction in which the object is moving or trying to move. The force of friction is a contact force since it arises due to two surfaces in contact.

Friction arises due to the irregularities in the two surfaces in contact. Even surfaces which appear smooth, have a large number of minute irregularities (Fig. 5.6). When placed in contact, the irregularities of two surfaces lock into each other and oppose any effort to move one surface over the other.



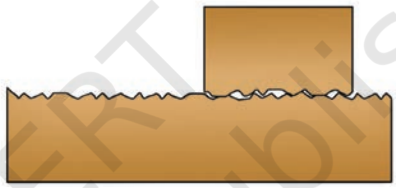



*Fig. 5.6: Friction between two surfaces due to irregularities*

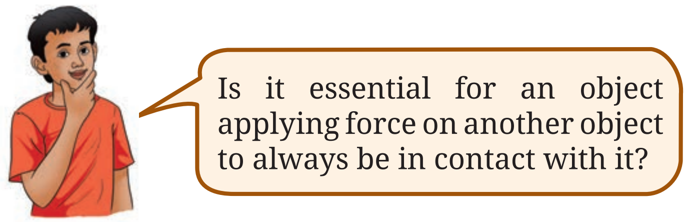
## Activity 5.4: Let us explore

- Try Activity 5.3 again, but this time place the same object on different surfaces, such as glass, cloth, wood, ceramic tile, and sand.
- Does the object stop after travelling the same distance as in Activity 5.3?
- Does the object stop at the same distance on all surfaces?

For different surfaces, the object stops after moving different distances so we can say that the force of friction depends upon the nature of the surfaces in contact. Friction is greater on rough surfaces.

### A step further

Does the force or friction act only if the objects are moving on solid surfaces? What about objects moving through liquids and gases? Air, water, and other liquids also exert force of friction on the objects moving through them. Hence the objects, such as aeroplanes, ships, boats, or high-speed trains are designed with specific shapes to reduce the force of friction due to the air or water around them.




### 5.4.2 Non-contact forces

There are forces whose effect can be experienced even if the objects are not in contact. These forces are called **non-contact forces**. Let us learn about non-contact forces.

#### Magnetic force

Do you remember learning about magnets in the chapter 'Exploring Magnets' in *Curiosity*, Grade 6? We learnt that a magnet attracts objects made of magnetic materials. When two magnets are brought close to each other, like poles (North–North, South–South) repel each other while unlike poles (North–South) attract each other. In an earlier chapter of this book, we also learnt about electromagnets which behave like magnets. Attraction and repulsion between objects are also a form of push and pull, that is, a force. Can you recall that a magnet could exert force on another magnet or a magnetic material without being in contact with it?

#### Activity 5.5: Let us test

- Take two ring magnets and a wooden stick.
- While holding the stick in a vertical position over a wooden table, insert one ring magnet onto the stick (Fig. 5.7).
- Now insert the second ring magnet above it such that the like poles of the two magnets face each other. Does the second magnet stay floating above the first magnet?
- Try pushing the second magnet down gently. Do you feel a force on it?
- Now, reverse the poles of both the magnets. Does the second magnet still remain floating?


*Fig. 5.7: Force between two ring magnets*

We find that a magnet can exert force on another magnet without being in contact with it.

The force exerted by a magnet on another magnet or a magnetic material is called **magnetic force**. Since a magnet can exert a force from a distance without being in contact it is called a non-contact force.

Are there more such forces which act from a distance?

## Electrostatic force

### Activity 5.6: Let us experiment

*Fig. 5.8: Charged plastic scale attracting small paper pieces*

- Take a plastic scale or a plastic straw, a piece of polythene, and small pieces of paper.
- Rub plastic scale/straw vigorously with polythene.
- Do not touch the rubbed part with your hand or any metal object.
- Now, bring it close to the small pieces of paper placed on a table, taking care not to touch the paper pieces (Fig. 5.8). Do you notice something surprising?

The paper pieces get pulled towards the plastic scale/straw and stick to it when it is brought close to paper pieces. Why does this happen?

When two objects of certain materials are rubbed together, electrical charges build up on their surfaces. These charges are called **static charges** as they do not move by themselves. The object that acquires static charges is said to be a **charged object**. A charged object attracts, that is, exerts a force on uncharged objects made of certain materials, such as small pieces of paper. This force comes into play even when the bodies are not in contact.

Let us do another activity with objects made of different materials.

### Activity 5.7: Let us experiment

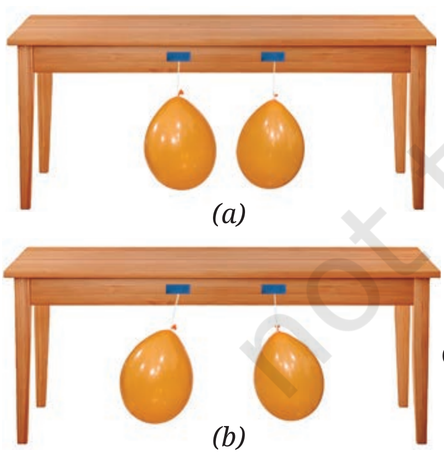



*Fig. 5.9: (a) Two uncharged balloons; (b) Two charged balloons repelling each other*

- Take two balloons, a length of thread, and a woollen cloth.
- Inflate two balloons and hang them in such a way that they do not touch each other as shown in Fig. 5.9a.
- Rub both balloons with the woollen cloth and release them. Be careful not to touch the rubbed balloons with your fingers. What do you observe?

We observe that the balloons move away from each other as if they are repelling each other (Fig. 5.9b).

- Now bring the woollen cloth used for rubbing the balloons close to one of the rubbed balloons. What happens?

They move towards each other as if they are attracting each other. What do we infer from these observations?


We found that the two similarly charged balloons repel each other whereas a charged balloon and the woollen cloth (with which the balloon was rubbed) attract each other. Does this **indicate** that the charge on the balloon is of a different kind from the charge on the woollen cloth?

Since the balloons were charged in the same way, we can say that they have acquired similar charges. As the similarly charged balloons repelled each other, we can infer that similar (like) charges repel each other. Both the rubbing object and the rubbed object get charged but they acquire opposite kind of charges. Their attraction shows that opposite kind (unlike) of charges attract each other. The two kinds of static charges are said to be 'positive' and 'negative'.

The force exerted by a charged body on another charged body or an uncharged body is called **electrostatic force**. It is a non-contact force.

### A step further

When the charges move, they constitute an electric current in an electrical circuit. It is the same current which makes a lamp glow or generates a heating effect or a magnetic effect.

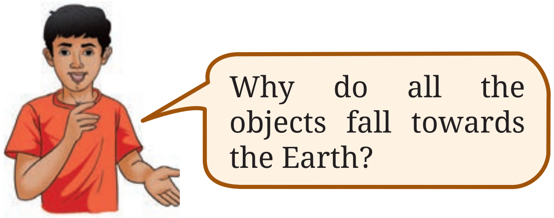
## Gravitational force

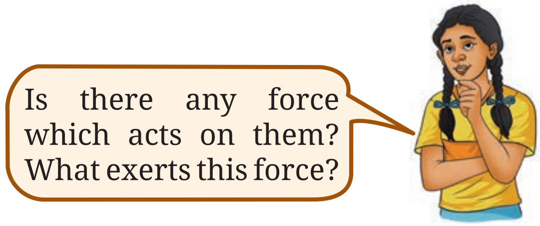
### Activity 5.8: Let us observe

- Take a ball and throw it vertically upwards. Does it come down?
- Now throw it again, but this time harder. Does it still fall back down to the ground?

Think about different situations around you where any object thrown up in any direction, finally falls or comes back to the ground or floor.

*Fig. 5.10: Some objects falling towards the Earth*




Since all the objects fall towards the Earth, it means the Earth attracts (pulls) them. The force with which the Earth attracts objects towards itself is called the **gravitational force**. The gravitational force exerted by the Earth is also called **force of gravity** or simply **gravity**.

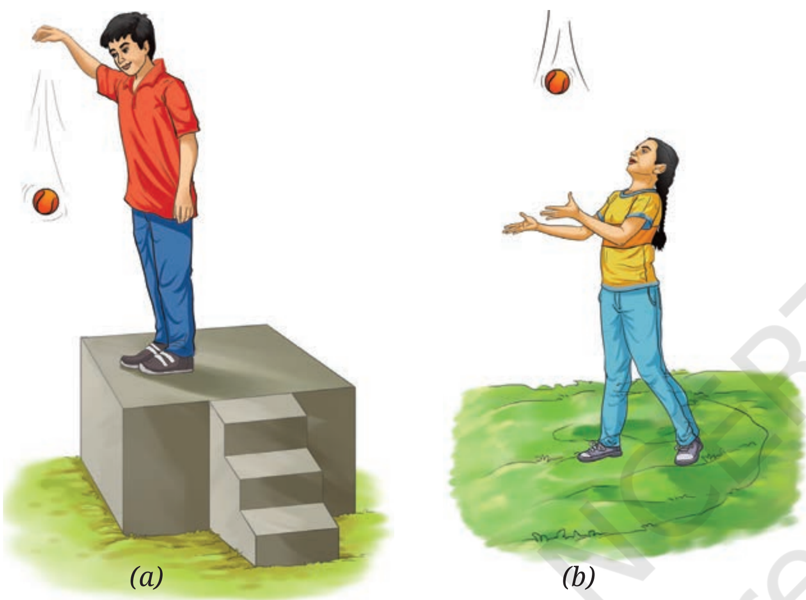
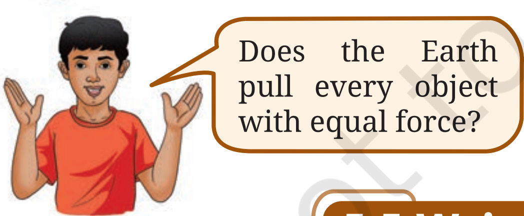



*Fig. 5.11: (a) Dropping an object from a height; (b) Throwing an object vertically upwards*

Since the gravitational force acts without contact with the object it attracts, it is a non-contact force. Gravitational force is always an attractive force, unlike magnetic force or electrostatic force, which can either be attractive or repulsive.

You might have noticed that when an object is dropped from a height, it takes a straight vertical path downwards before touching the ground (Fig. 5.11a). When an object is thrown vertically upwards, the object moves up straight, slows down, stops momentarily at the top, and then takes a straight vertical path downwards (Fig. 5.11b).

While going up, the speed of the object goes on decreasing till the object comes to a stop, its direction of motion changes and while coming down the speed goes on increasing. We say that the object undergoes a **vertical motion** when it moves in a vertical direction under the influence of the gravitational force.




## 5.5 Weight and Its Measurement

The force with which the Earth pulls an object towards itself is called the **weight** of the object. The weight measures how strongly an object is pulled by the Earth. Since the weight is a force, it is measured in the same unit as that of force. Therefore, **SI unit of weight** is also **newton (N)**.

Let us now try to find out if the Earth pulls every object with equal force.

## Activity 5.9: Let us explore

- Take a spring and a few objects of different masses, such as a pencil box, a tiffin box, and a small stone.
- Hang one end of the spring from a nail. From the other end, hang an object and observe the spring. Does the spring stretch?
- Now hang the other objects, one by one and notice the stretch in the spring each time. Is the stretch caused by each object the same?

When an object is hung from a spring, the spring stretches due to the force applied on the object by the Earth. We find that the stretch caused in the spring is different for different objects. This indicates that the Earth pulls different objects with different forces, that is, the weight of different objects is different. Can we use the spring to measure the weight of an object?

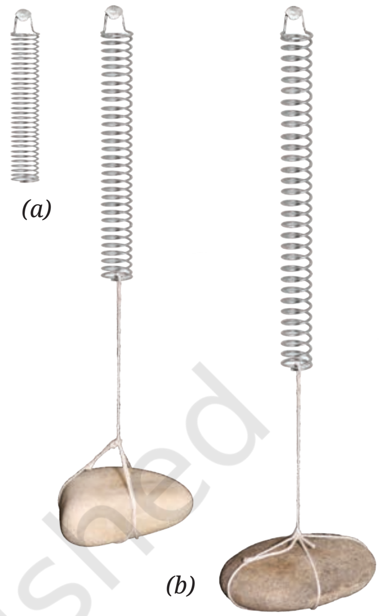


*Fig. 5.12: (a) A hanging spring; (b) Two different objects hung from the spring*

### A step further

A spring balance is a simple device used to measure weight (force). It consists of a spring fixed at one end, with a hook attached at the other end. When we hang an object from the hook, the spring stretches, and the amount of stretching gives the weight of the object. There is a scale on the balance which is marked to show the weight (force) in newton. Usually, there is also another scale to show the corresponding values of mass in gram (g). These values have been marked with the assumption that the spring balance is used on the Earth, with the Earth's gravitational force attracting the object.

Let us learn to measure the weight using a **spring balance**. But first, let us familiarise ourselves with a spring balance the way we did with thermometer earlier (in the chapter 'Temperature and Its Measurement' in *Curiosity*, Grade 6).

## Activity 5.10: Let us observe

- Look at the spring balance shown in Fig. 5.13 carefully. What is the maximum weight it can measure?

The maximum weight it can measure is 10 N. Thus, this scale has a range of 0 to 10 N.

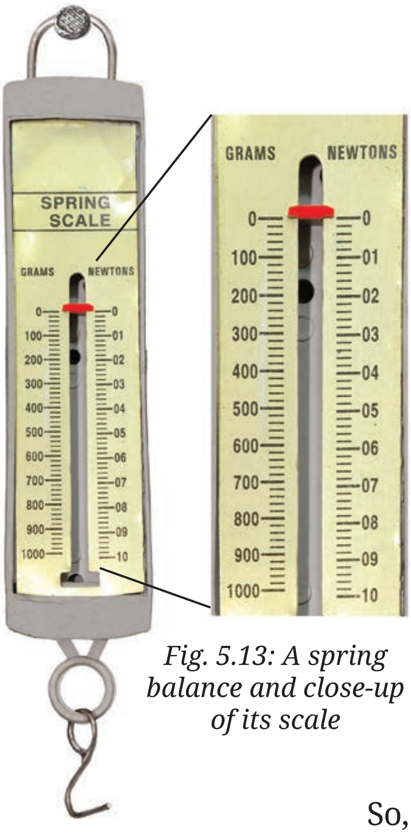


Fig. 5.13: A spring balance and close-up of its scale

Let us now try to find the smallest value of weight that can be measured by the spring balance.

## Activity 5.11: Let us calculate

- Look at the spring balance shown in Fig. 5.13 and note down the following:
    - How much is the weight difference indicated between the two bigger marks?

  The weight difference indicated between 0 and 01 N or between 01 N and 02 N is 1 N.
    - How many divisions (shown by smaller marks) are there between these two bigger marks?

  There are 5 divisions between these marks.
    - How much weight does one small division indicate?

  One small division can read $\frac{1\ \text{N}}{5} = 0.2$ N.

So, the smallest value that the spring balance can read is 0.2 N.

Now using this method, calculate the smallest value of weight that can be measured with the spring balance given to you. Your school laboratory may have spring balances for which the range and the value of the smallest division may be different. It is, therefore, always necessary to look carefully at the spring balance (or any other instrument) you are about to use.

Let us now learn how to **measure** weight using a spring balance.

## Activity 5.12: Let us measure

- Take a spring balance and a few objects. Keep in mind that the objects should not be heavier than the maximum value of weight the spring balance can measure, otherwise it may get damaged.
- Suspend the objects one by one from the hook (Fig. 5.14). Read the scale for weight carefully and record your observations in the Table 5.2.

Fig. 5.14: Object suspended from a spring balance

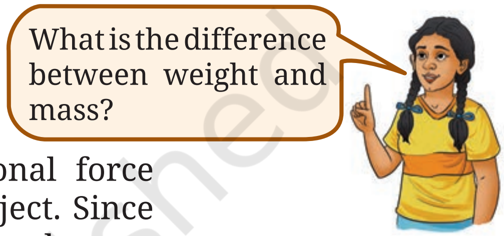
**Table 5.2: Measuring weight using a spring balance**

| S.No. | Object | Weight (N) |
|---|---|---|
| 1. | Pencil Box | |
| 2. | Partially filled water bottle | |
| | | |

You can repeat Activities 5.10 to 5.12 for the mass scale shown on the left side on the spring balance (Fig. 5.13) to measure the mass of an object.

### A step further

The mass of an object can be measured indirectly by measuring its weight (using a spring balance) or by comparing its weight with the weight of an object of a known mass (using a beam balance). Since the weight of an object remains almost the same everywhere on the Earth, so for all practical purposes it is acceptable to weigh an object to find its mass.




As we have learnt earlier (in the chapter 'Materials Around Us' in *Curiosity*, Grade 6), mass is the amount of matter in an object and is measured in grams (g) or kilograms (kg). Its value remains the same at every place. Weight, on the other hand, is the gravitational force with which the Earth (or another planet) pulls an object. Since gravitational force can vary very slightly from place to place on the Earth (and can be very different on different planets), weight can change, but mass does not.

### A step further

The gravitational force of different planets on an object is different. Thus, the weight of an object is different on different planets, as shown in the following table, even though its mass remains the same.

| Planet | Earth | Moon | Mars | Venus | Jupiter |
|---|---|---|---|---|---|
| Mass of the object | 1 kg | 1 kg | 1 kg | 1 kg | 1 kg |
| Weight of the object | 10 N | 1.6 N | 3.8 N | 9 N | 25.4 N |

### A step further

In everyday life, particularly for the goods we commonly use, we are more interested in the amount of matter in an object (its mass), rather than the force applied by the Earth upon it (its weight). However, though while the units of mass are used, instead of the term mass, the term weight is typically used. For example, it is said that the weight of the wheat bag is 10 kg. But in scientific use, this is not correct and it is important to use the correct terms with their correct units, even if every day language is more casual.

## 5.6 Floating and Sinking

If we place some objects on water, some of them float, while others fall to the bottom. The gravitational force of the Earth is acting on all objects, then why don't all objects fall to the bottom?

While taking out water from a bucket filled with water using a mug, do you notice that the mug feels lighter when it is inside water? Let us try to **understand** this.

### Activity 5.13: Let us investigate

- Take an empty plastic bottle (with its lid closed tightly) and a bucket full of water.
- Push the bottle in the water (Fig. 5.15). Do you feel an upward push? Release the bottle. Does it bounce up?

*Fig. 5.15: Plastic bottle in water*

You would have felt an upward push and the bottle bounces back to the surface of the water. This indicates that water applies a force on the bottle in the upward direction. In fact, all liquids apply a similar force. The force applied by a liquid on an object in the upward direction is known as **upthrust** or **buoyant force**.

When an object is placed in a liquid, the gravitational force due to the Earth acts on it downwards. But a buoyant force is applied on it by the liquid in the upward direction. If the gravitational force is more than the buoyant force, the object **sinks**, but if the two forces are equal, the object **floats**. One of the factors on which the buoyant force depends upon, is the density of the liquid. You will learn about density in a later chapter of this book.

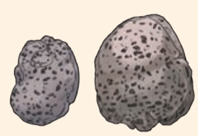


### A step further

Archimedes, a famous Greek scientist, discovered that when an object is fully or partially immersed in a liquid, it experiences an upward force which is equal to the weight of the liquid it displaces. This is known as Archimedes' Principle. If the weight of a liquid displaced by an object is smaller than the weight of the object, the object will sink in the liquid. If the weight of the liquid displaced is equal to the weight of the object, the object will float in the liquid.

### Ever heard of ...

There are some rocks which can float on water. One such rock is Pumice, which is formed during volcanic eruptions. When lava with lots of gas and water vapour cools quickly, it traps tiny bubbles of gas inside. This creates a light, porous rock— filled with air pockets which is less dense than water and floats on it.



## Snapshots

- A force is push or pull on an object resulting from the object's interaction with another object.
- The SI unit of force is newton and its symbol is N.
- Forces can act with or without contact.
- Muscular force and frictional force are some of the examples of contact forces.
- Magnetic force, gravitational force, and electrostatic force are non-contact forces.
- Force can change an object's speed, direction of its motion, or both. Force can change the shape of an object.
- The force which comes into play when an object moves or tries to move over another surface, is called force of friction or simply friction. It acts in a direction opposite to the direction in which the object is moving or trying to move.
- The force exerted by a magnet on another magnet or a magnetic material is called magnetic force.
- The force exerted by a charged body on another charged body or uncharged body is called an electrostatic force.
- The force with which the Earth attracts objects towards itself, is called the gravitational force. It is always an attractive force.
- The force with which the Earth pulls an object towards itself is called the weight of the object. The SI unit of weight is newton (N).
- The mass of an object remains unchanged whereas its weight may vary from place to place.
- When an object is placed in a liquid, the force applied by a liquid on an object in the upward direction is known as upthrust or buoyant force.

## Keep the curiosity alive

1. Match items in Column A with the items in Column B.

| Column A (Type of force) | | Column B (Example) | |
|---|---|---|---|
| (i) | Muscular force | (a) | A cricket ball stopping on its own just before touching the boundary line |
| (ii) | Magnetic force | (b) | A child lifting a school bag |
| (iii) | Frictional force | (c) | A fruit falling from a tree |
| (iv) | Gravitational force | (d) | Balloon rubbed on woollen cloth attracting hair strands |
| (v) | Electrostatic force | (e) | A compass needle pointing North |



**Prepare some questions based on your learnings so far ...**

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2. State whether the following statements are True or False.
   (i) A force is always required to change the speed of motion of an object.
   (ii) Due to friction, the speed of the ball rolling on a flat ground increases.
   (iii) There is no force between two charged objects placed at a small distance apart.
3. Two balloons rubbed with a woollen cloth are brought near each other. What would happen and why?
4. When you drop a coin in a glass of water, it sinks, but when you place a bigger wooden block in water, it floats. Explain.
5. If a ball is thrown upwards, it slows down, stops momentarily, and then falls back to the ground. Name the forces acting on the ball and specify their directions.
   (i) During its upward motion
   (ii) During its downward motion
   (iii) At its topmost position
6. A ball is released from the point P and moves along an inclined plane and then along a horizontal surface as shown in the Fig. 5.16. It comes to stop at the point A on the horizontal surface. Think of a way so that when the ball is released from the same point P, it stops (i) before the point A (ii) after crossing the point A.

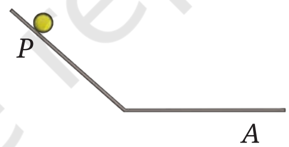
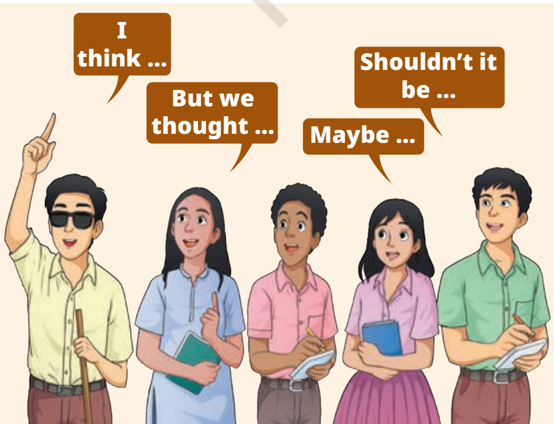



*Fig. 5.16*

7. Why do we sometimes slip on smooth surfaces like ice or polished floors? Explain.
8. Is any force being applied to an object in a non-uniform motion?
9. The weight of an object on the Moon becomes one-sixth of its weight on the Earth. What causes this change? Does the mass of the object also become one-sixth of its mass on the Earth?






**Reflect on the questions framed by your friends and try to answer ...**

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10. Three objects 1, 2, and 3 of the same size and shape but made of different materials are placed in the water. They dip to different depths as shown in Fig. 5.17. If the weights of the three objects 1, 2, and 3 are $w_1$, $w_2$, and $w_3$, respectively, then

(i) $w_1 = w_2 = w_3$

(ii) $w_1 > w_2 > w_3$

(iii) $w_2 > w_3 > w_1$

(iv) $w_3 > w_1 > w_2$

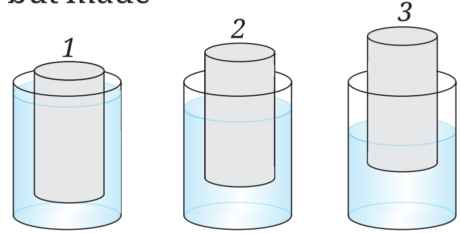
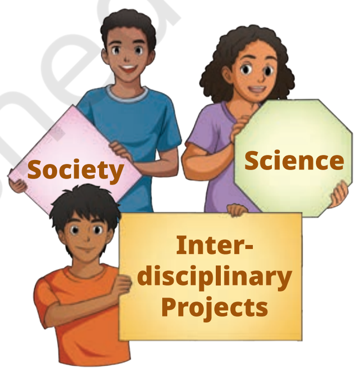


Fig. 5.17

## Discover, design, and debate




- Collect objects made of different materials, such as plastic, wool, silk, rubber, polythene sheet, paper, and metals. Rub one material with another and check if it attracts small pieces of paper or not, that is, whether it gets charged or not. Record your observations in a systematic manner and write a research paper.
- Imagine a scenario where the gravity disappears. Develop a story. Create a cartoon strip to present your story.
- Organise a discussion in your class on the topic: Friction — a necessity or a problem? Make a note of the discussion and state where friction is a necessity and when it is a problem.
- Make your own spring balance with the help of your teacher and calibrate it using standard weights. Now measure the weights of different objects and calculate the ratio of the weight and mass of different objects. Do you observe a pattern?
- An electroscope is a device which can determine whether an object is electrically charged. You can make your own electroscope (Fig. 5.18) in your class with the help of your teacher, test the device. Explore in what other ways you may use this electroscope.

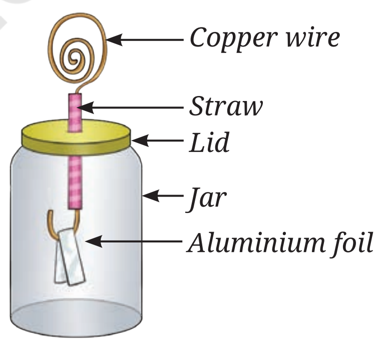


Fig. 5.18

# 6 Pressure, Winds, Storms, and Cyclones



## Probe and ponder

- Why are winds stronger on some days than on others?
- Why are water tanks usually placed at a height?
- Can air pressure really crush us?
- What causes storms and cyclones? If the Earth stopped rotating, would cyclones still form?
- Share your questions

  ______________________________

  ______________________________ ?

You must have observed fallen leaves on the ground swirling in the air or being swept away, and trees swaying or even bending when a strong wind blows. Have you ever wondered why fallen leaves rise in the air or trees sway or bend? Does the wind exert force on fallen leaves to make them rise or on trees to bend? Recall other similar effects of the force exerted by wind like slamming of doors or rattling of windows, or fluttering of clothes? How does the force exerted by wind make this happen? The force exerted by wind creates wind pressure which causes these effects. In this chapter, we will **explore** the relationship between force and pressure, and understand how they shape powerful natural events like thunderstorms and cyclones.

## 6.1 Pressure

Megha and her brother Pawan are going on a picnic. They walk to the picnic spot, carrying identical items in their bags (Fig. 6.1). On the way, Pawan keeps adjusting his bag, and looks uncomfortable. Megha asks, "Is there a problem with your bag?" Pawan responds, "Yes, it is hurting my shoulders." Megha says, "Both our bags are equally heavy. Why does your bag hurt, and mine doesn't?" Pawan reflects for a minute and says, "Perhaps, it is because of the difference in the straps of our bags. My bag has narrow straps while your bag has broad straps."


*Fig. 6.1: Megha and Pawan carrying their bags*

Can the shape or size of the straps really make a difference? Let us try to find out.

When we carry a bag, we feel its weight because of the force of gravity acting on our shoulders. The weight of the bag with **narrow straps** acts on a **smaller area** of our shoulders, whereas the weight of the bag with **broad straps** is spread out over a **larger area** of our shoulders. It is due to this reason that we feel more comfortable carrying a bag with broader straps than one with narrow straps, although both bags have the same weight. Since the area over which the force acts is involved, we define a quantity called **pressure**, which is the **force per unit area**.

So, $$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

At this stage, we will consider only those forces which act perpendicular to the surface on which the pressure is to be computed.


*Fig. 6.2: Buckets with broad and narrow handles*

*Fig. 6.3: Persons carrying loads*

Broad straps reduce the pressure exerted by the bag on our shoulders as compared to narrow straps. Therefore, we feel more comfortable carrying a bag with broad straps.

Can you now understand why it feels easier to lift a water-filled bucket with a broad handle than with a narrow handle (Fig. 6.2)? Similarly, we have seen that when people carry loads like pots or vegetable baskets on their heads, they often place a round piece of cloth under the loads (Fig. 6.3). In both cases, the objective is to reduce pressure by increasing the area over which the weight acts.

Pressure is defined as the force per unit area. The **SI unit** of **force** is **newton** and that of **area** is **metre**$^2$. Therefore, the **SI unit** of **pressure** is **newton/metre**$^2$ **(N/m**$^2$**)**. This unit is also called a **pascal**, denoted by **Pa**.

If a force of 100 N is applied on a cardboard of area 2 m$^2$, then the pressure applied on the cardboard will be:

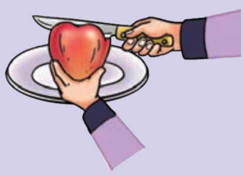
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{100 \text{ N}}{2 \text{ m}^2} = 50 \text{ N/m}^2$$

There are many situations in daily life where pressure plays a role. **Conduct** the activities given in Table 6.1 and **record** your observations. **Explain** how pressure influences the mode of action undertaken for each activity.

**Safety first**

The activities listed in Table 6.1 should be conducted under the supervision of an adult.

**Table 6.1: Record your observations**

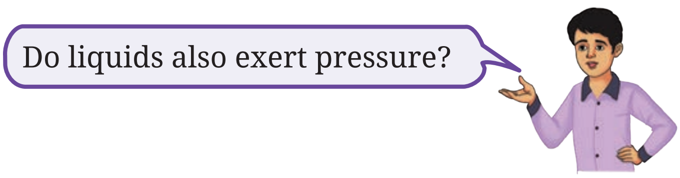
| Activity | Modes of action | | Easy or difficult to perform? Give reasons. |
|---|---|---|---|
| Driving an iron nail |  By the head of the nail |  By the pointed end of the nail | |
| Cutting an apple with a knife |  Using the sharp edge of the knife |  Using the blunt edge of the knife | |

What can you **conclude** from your observations in Table 6.1?

We conclude that when the area over which a force applied is smaller, the resulting pressure is higher, making it easier to do certain tasks. This is why it is easier to drive a nail using its pointed end, and it is easier to cut an apple with the sharp edge of a knife.

Fig. 6.4: Overhead tank

You must have seen overhead water tanks (Fig. 6.4) in your locality, or on the rooftops of houses used for water supply. Why are these tanks always placed at a height?




Let us find out by conducting the following activity.

## Activity 6.1: Let us try and find out

- Take two transparent glass or plastic pipes of the same length (about 25 cm), but of different diameters, as shown in Fig. 6.5.
- Take two good-quality rubber balloons. Attach them to one end of each pipe.
- Clamp the pipes on a stand as shown in Fig. 6.5.
- Now, fill both the pipes with water up to the same level about halfway.
- **Observe** what happens to the balloons.
- Do both balloons bulge? Do they bulge to the same extent?

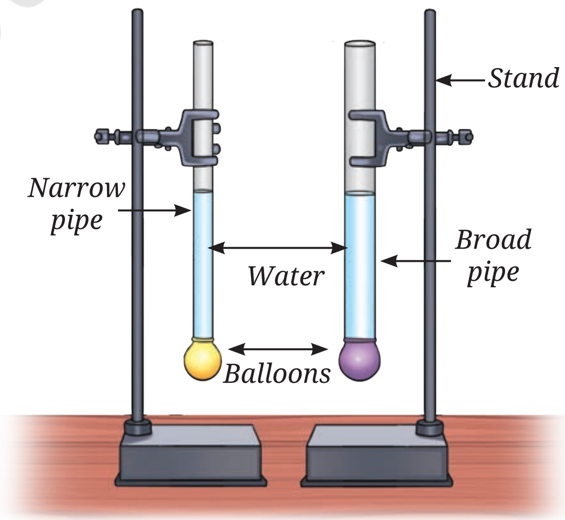



Fig. 6.5: Equal heights of water columns produce same bulge in balloons

What can you **infer** from this activity? You must have observed that the two balloons bulge to the same extent. Why is it so? Notice that because of the different diameters, the weight of water in the two pipes is different. However, the bulge in both the balloons is the same. This means that the weight of water in the pipes could not be responsible for the extent of the bulge of the balloons.

Could it be that the water column is exerting pressure? Yes, it is the pressure exerted by the water column which is responsible for the bulge. That is why equal water column heights produce equal bulges in the balloons, despite their different diameters.

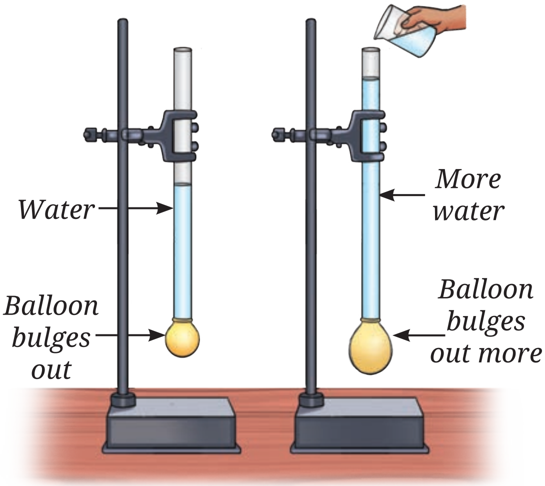
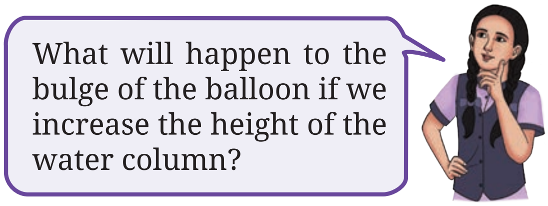



*Fig. 6.6: Higher heights of water column produce bigger bulge of the balloon*




Pour some more water in any one of the pipes used in Fig. 6.5. Observe the bulge of the balloon. Repeat this process a few times, adding more water each time and noting the extent of bulge as shown in Fig. 6.6.

Do you see any relation between the amount of bulge of the rubber balloon and the height of the water column in the pipe? You must have observed that the bulge of the balloon increases as the height of the water column increases.

Thus, as the height of the water column in the pipe increases, the pressure at the bottom of the pipe also increases, which causes the balloon to bulge more. So, we can say that the pressure exerted by a liquid in a vessel depends on the height of its column. This is the reason why overhead tanks are placed at a height so that the pressure in the taps is increased, resulting in a good stream of water from the taps.

Suppose you are living on the second floor of a three-storeyed building and an overhead water tank is placed on the top floor. Will you or your friend on the first floor receive a more powerful stream of tap water? Give reasons.

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Do liquids also exert pressure on the walls of the container? Let us find out by conducting the following activity.

## Activity 6.2: Let us find out

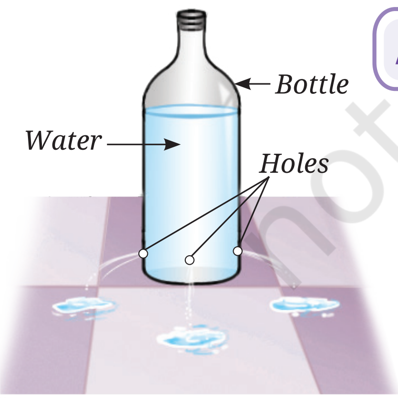



*Fig. 6.7: Liquid exerts pressure on the wall of the container*

- Take a used plastic bottle and remove its cap. Make four small holes near the bottom around the sides using a needle or a nail. Make sure that the holes are at the same height from the bottom as shown in Fig. 6.7. (If you find it difficult to make a hole, you can slightly heat the needle and poke it to make holes.)
- Seal the holes with a tape and fill the bottle with water.
- Now, remove the tape from all holes at the same time.
- What do you observe?

You observe water flowing out through the holes on the sides of the bottle. What can you infer from this observation? It **indicates** that water also exerts pressure on the sides of a container. Therefore, we can conclude that liquids exert pressure not only at the bottom of the container, but also on its sides. In fact liquids exert pressure in all directions.

You must have seen water spurting out like a fountain from leaking joints or holes in water pipes. Can you explain why this happens? Is it due to the pressure exerted by water on the walls of the pipes?

### Ever heard of ...

Do you know that the base of a dam is much broader than the top? This is because a broad base not only supports the structure of the dam, but also withstands the horizontal water pressure near the bottom (Fig. 6.8). The water stored in the dam, exerts pressure horizontally on the side walls of the dam and vertically on the floor due to the height of the water level. The pressure which acts horizontally, is very large near its bottom. Thus, to withstand the pressure, the base of the dam is made broader.

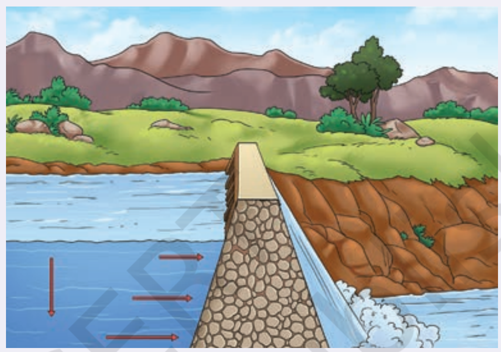


*Fig. 6.8: Dam*

Let us now try to understand if air also exerts pressure.

## 6.2 Pressure Exerted by Air

You already know that air is all around us. The envelope of air surrounding the Earth is called **atmosphere**. The atmospheric air contains nitrogen, oxygen, argon, carbon dioxide, and other gases in small quantities. The atmosphere extends up to many kilometres above the surface of the Earth.

Let us find out if the atmosphere exerts pressure by performing the following activity.

### Activity 6.3: Let us explore

- Take a paper plate, invert it and attach a stick to it as shown in Fig. 6.9a. Place it on a plain surface.
- Take two identical sheets of chart paper about 70 cm × 56 cm each. Fold one sheet twice and make a hole in the centre of

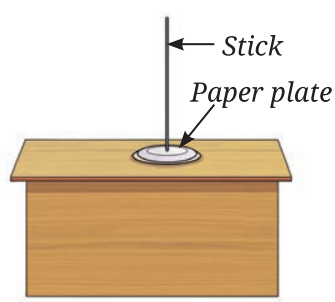



*Fig. 6.9: (a) Inverted paper plate setup*

*Fig. 6.9: (b) Inverted paper plate with two folds of chart paper*

the folded chart paper sheet—big enough for the stick to come out. Place the folded sheet on top of the inverted paper plate as shown in Fig. 6.9b.

- Now, try to lift the paper plate covered with a folded sheet using the stick.
- Observe how much effort is needed to lift it.
- Now, place the second unfolded chart paper sheet in place of the folded sheet. Make a hole at the centre of this chart paper for the stick to pass through. Cover the paper plate with the unfolded chart paper as shown in Fig. 6.9 c.
- Lift the paper plate again and feel the effort needed in doing so.
- In which case is the lifting easier, with the folded or the unfolded chart paper covering the paper plate?

*Fig. 6.9: (c) Inverted paper plate with unfolded chart paper*

You would have observed that more effort is needed to lift the paper plate when it is covered with the unfolded chart paper, than with the folded chart paper. When we cover the paper plate with unfolded chart paper, the area of the covering sheet increases. The effort needed to lift the paper plate increases. Notice that the weight of the covering sheet has not changed. What can you infer from this? We can infer from these observations that air exerts force on the covering sheet, which makes it difficult to lift the paper plate. Moreover, this force increases with increase in the area of covering sheets. It means that the air is exerting a force on the paper plate, which increases as the area of the sheet covering it increases. As force per unit area is pressure, we can conclude that air exerts pressure on the paper sheet. In fact, air exerts pressure on all objects. The pressure exerted by air around us is known as the **atmospheric pressure**.

*Fig. 6.10: A girl blowing a balloon*

You must have experienced that when you blow air into a balloon, it gets inflated. Why? This is because the air being filled inside the balloon exerts pressure on the walls of the balloon (Fig 6.10). Can we say that air exerts pressure in all directions? Yes, that is why the balloon expands in all directions. What happens when an inflated balloon is kept without closing its mouth? The air escapes from the balloon. Why does the air escape from the balloon?

Have you ever wondered how large the atmospheric pressure is? Let us get an idea about its magnitude by performing the following activity.

## Activity 6.4: Let us perform

- Take a good-quality rubber sucker. Press it firmly against a smooth flat surface (Fig. 6.11).
- Do you realise that it sticks to the surface?
- Now, try to pull it off. Do you find it difficult to pull it off?

*Fig. 6.11: A sucker*

When we press the sucker, most of the air between its cup and the surface on which it is placed is pushed out and the air pressure inside it is reduced. The sucker sticks to the surface because the pressure of air surrounding the sucker is higher than the pressure exerted by the air inside the sucker. To pull the sucker off the surface, the applied force should be strong enough to overcome the pressure difference between outside the sucker and inside the sucker.

Do you know how large the atmospheric pressure is? The force exerted by the atmospheric air column over an area 15 cm × 15 cm is nearly equal to the force of gravity on an object of mass 225 kg (2250 N). The reason we are not crushed under this weight is that the pressure inside our bodies is also equal to the atmospheric pressure. This balances the pressure exerted from outside. The pressure inside our body is caused by the movement of fluids and gases in tissues and organs of the body.

### A step further

The SI unit of pressure is $N/m^2$, also known as pascal (Pa). However, the practical unit of air pressure is millibar (mb), which is equal to 100 Pa. Air pressure is also expressed in hectopascal (hPa), which is equal to 100 Pa.

## 6.3 Formation of Wind

You must have noticed that on some days, the wind blows strongly, whereas on other days, it is calm. Sometimes, wind becomes so strong that it causes damage to life and property.

You must have seen that when an inflated balloon is kept without closing its mouth, the air from the balloon escapes. Recall that when there is a puncture in the bicycle tube, the air escapes and the tube collapses. In both of these cases, does air move from a high pressure region to a low pressure region?



Let us find out from the following activity.

## Activity 6.5: Let us observe

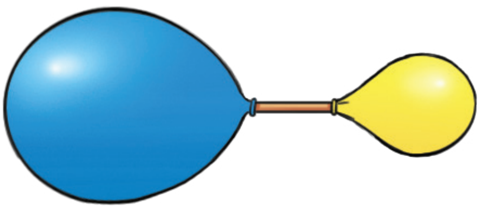


*Fig. 6.12: Air moves from a high pressure region to a low pressure region*

- Take two similar balloons made of thin rubber, and a drinking straw.
- Insert one end of the straw into one balloon and secure it with a rubber band or thread.
- Now inflate the second balloon and hold its mouth with your fingers, so that air does not escape.
- Insert the free end of the straw into the neck of the inflated balloon and secure it with a rubber band or thread. Make sure that the air does not leak from the balloon as the straw is inserted in it. Now you have one end of the straw inside the inflated balloon and the other end inside the uninflated balloon as shown in Fig. 6.12.
- **Predict** what would happen to the balloons.
- Observe what happens to both the balloons. Did it happen as predicted?
- Do you observe any change in the size of the balloons? Write down your observations.

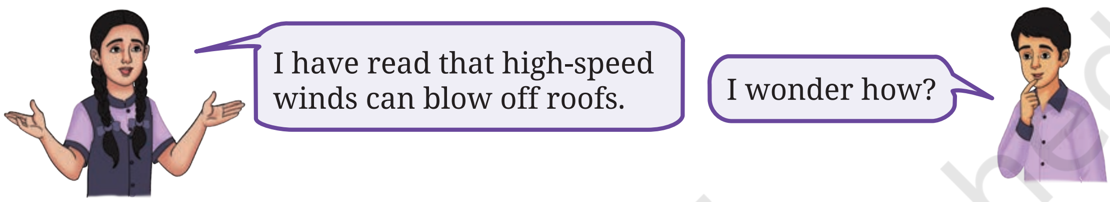
..............................................................................................................

What can be the reason for the change in the sizes of the balloons? The air pressure in the inflated balloon is higher than that in the uninflated balloon. As a result, some air moves from the inflated balloon to the uninflated balloon, resulting in changes in the size of both the balloons.

Do you notice that after some time both the balloons attain almost the same size and the flow of air stops? Why does the air flow stop? The flow of air continues till the air pressure in the inflated balloon is higher than the air pressure in the uninflated balloon. The air flow stops when the pressure in both balloons becomes equal. At this stage, both balloons are almost of the same size. Thus, we can conclude that air moves from a region of high air pressure to a region of low air pressure.

You can relate this conclusion to the directions of the sea breeze and land breeze, which you studied in *Curiosity*, Grade 7. As land gets heated faster than water during the day, the air above the land becomes warmer and lighter. Hence, it rises, creating an area of low pressure. The air from the high pressure region of the sea blows to the low pressure region which develops on the land, resulting in a sea breeze. At night, the water is warmer than the land. Therefore, a low pressure area develops above the sea. As a result, wind blows from the land to the sea, giving rise to land breeze. Thus, the phenomenon of land breeze and sea breeze is mainly due to the pressure differences over the land and the sea.

If we could measure the speed of the escaping air in Activity 6.5, we would find that the speed of the air is higher if the pressure difference is higher.




## 6.4 High-Speed Winds Result in Lowering of Air Pressure

### Activity 6.6: Let us observe

- Take two balloons of the same size.
- Inflate both balloons and tie strings to them.
- Hang the two balloons from a stick, leaving a gap of 6–10 cm (Fig. 6.13).
- Now, blow air into the narrow space between the balloons.
- What happens to the balloons? Note down your observations.
- Now blow harder and observe.

*Fig. 6.13: Blowing between two balloons*

When you blow between the two balloons, you observe that they move towards each other. This happens because when you blow air between the balloons, a low pressure area is created between them. The higher air pressure surrounding the balloon pushes them towards each other. You must have observed that blowing harder increases the speed at which the balloons approach each other. What can you infer from this activity? We infer that high speed winds are accompanied by a reduced air pressure.

Fig. 6.14: (a) Roof of a house blown away

Fig. 6.14: (b) Roof of a house intact

When high-speed winds blow over houses, a low-pressure area is created over them, as high-speed winds are accompanied by a reduced pressure. Therefore, the air pressure above the roofs of the houses is lower than the pressure below them. If the pressure difference is large and the roofs are weak, they may be blown away, as shown in Fig. 6.14a. That is why it is safer to keep doors and windows of the houses open during storms with high-speed winds. When the same wind moves over the roofs, and through the houses, the pressure difference between inside of the houses and over the roofs is reduced to a large extent. This helps prevent the roofs from being blown off as shown in Fig. 6.14b.

You must have experienced that when high-speed winds blow during storms, they are sometimes accompanied by thunder and lightning. Let us learn more about them.

## 6.5 Storms, Thunderstorms, and Lightning

Have you heard the sound of thunder and seen lightning during the rainy season?

Yes, the sound of thunder is so frightening! Usually there is heavy rainfall too.

When land gets heated, the warm and moist air, being lighter, rises, thereby creating a low pressure area. Cooler air from the surrounding high-pressure areas flows to take its place. This air, in turn, gets heated and rises. This results in a continuous process of wind circulation. As the rising air expands, it cools and moisture in it condenses to form water droplets, creating clouds. The water droplets merge to form heavier drops, which come down as rain, hail, or snow. The strong winds accompanied by rain is called a **storm**. In hot, humid, and tropical regions like India, storms are more frequent. Under certain conditions, warm air rises to great heights that the low temperature there converts water droplets into ice particles.

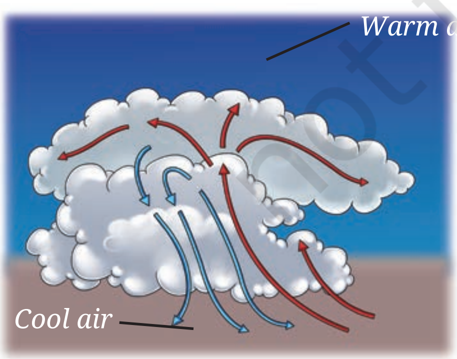



Fig. 6.15: Strong winds going up and down

Strong winds blowing upwards and downwards (Fig. 6.15) facilitate rubbing between water droplets and ice particles. You have learnt in the chapter 'Exploring Forces' that when two objects are rubbed against each other, they get charged. In this case, strong winds blowing upwards and downwards and rubbing against each other cause static electric charges to develop within the clouds.


Fig. 6.16: Lightning

The positively charged lighter ice particles move upwards and occupy the upper part of the clouds. The negatively charged heavier water droplets occupy the lower part of the clouds. Thus, a charge separation within the cloud takes place. Also, when the negatively charged lower part of the cloud moves closer to the ground, it causes the ground and nearby objects, such as trees or buildings, to become positively charged (Fig. 6.16).

Normally, air acts as an electrical insulator and does not let opposite charges meet. But when the build up of charges becomes very large, the insulating property of air breaks down. A sudden flow of charges takes place, producing a bright flash of light called **lightning**.

Lightning can occur as opposite charges collide within a cloud, between clouds, or between clouds and the ground. Lightning rapidly heats up the air around it, causing the air to expand and produce a loud sound known as **thunder**. A storm accompanied by lightning and thunder is called a **thunderstorm**.

## A step further

Isolated and localised thunderstorms can sometimes occur in various regions of India. These thunderstorms are known by various names such as *Kalboishakhi* in West Bengal, Bihar, and Jharkhand and *Bordoisila* in Assam. They occur before the arrival of the monsoon, thereby helping kharif crops to grow. In Kerala, Karnataka, and Tamil Nadu, they are known as mango showers as they support the ripening of mangoes. Local thunderstorms in Karnataka help in the growth of coffee plants.

Lightning can be dangerous! It can ignite fires, damage buildings, and cause severe burns or death in humans and animals. We must take necessary precautions and protect ourselves from lightning. During lightning, stay away from tall objects, find a low-lying open area and crouch down, and minimise contact with the ground. Do not lie down flat. Avoid using an umbrella with a metallic rod. If you are in water, get out of it. If you are inside a bus or a car, you are comparatively safer.


Fig. 6.17: Safe position during lightning

## Ever heard of ...

A lightning conductor is a metallic rod installed along the walls of buildings during their construction. One end of the rod is pointed. This end is kept higher than the highest point of the building (Fig. 6.18). The other end of the rod is buried deep in the ground. The rod provides easy path for the transfer of electric charges into the ground.

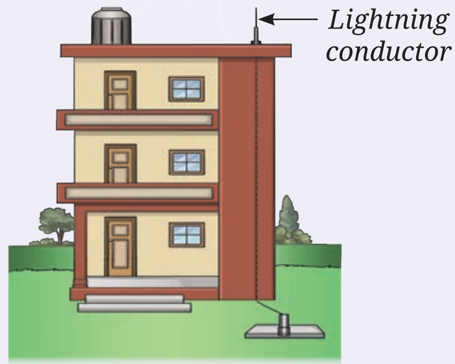


Fig. 6.18: A lightning conductor

## 6.6 Cyclone

**Cyclones** are large storms that form over warm ocean waters. As the ocean water gets heated, the warm and moist air above it rises. As the moist air rises, the water vapour condenses to form raindrops. We know that during evaporation, water takes up heat to change into vapour. When this water vapour condenses into raindrops, heat is released back into the atmosphere. This causes further warming of the ascending air leading it to rise even further, creating an even lower pressure. Air from the surrounding regions rushes in and it also starts rising. Earth's rotation causes the moving air to spin (Fig. 6.19). This cycle is repeated, resulting in the creation of a very low-pressure area with high-speed winds revolving around it. This spinning system of clouds, winds, and rain is called a **cyclone**.

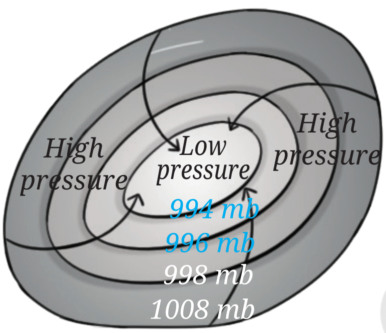


Fig. 6.19: Winds blowing from high pressure areas to low pressure areas

In a cyclone, the region of lowest pressure is at the centre, known as the **eye of the cyclone**. At the eye of the cyclone, the wind is calm, but the surrounding region experiences strong winds and heavy rainfall. As a cyclone moves from the ocean towards the land, it generates higher wind speeds compared to the wind speeds produced by regular thunderstorms. Once the cyclone reaches land, the source of moist air is cut off and it gradually loses its strength.

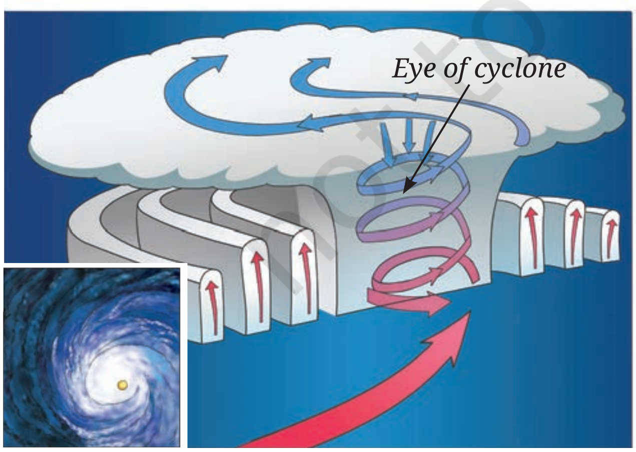


Fig. 6.20: A cyclone

Even as a cyclone loses its strength while travelling over land, it leaves behind a trail of destruction that can take months or even years to repair. Cyclones can be extremely destructive. For example, the Amphan cyclone in 2020 had peak wind speeds of 270 km/h.

Strong winds during a cyclone push ocean water towards the shore, creating a wall of water that can be as high as 3–12 metres. This surge of water can flood coastal areas and even areas far from the sea. The heavy rainfall which accompanies a cyclone may cause rivers to overflow and can also trigger landslides.

Seawater that rushes inland can contaminate drinking water sources and damage farmland. The salt in seawater can make soil less fertile, affecting crops. Roads may get blocked due to fallen trees and debris, making it difficult for help to reach the affected areas. Power outages can last for days, disrupting emergency services and daily life.

How can we protect ourselves during cyclones? It is important to stay updated on weather reports and periodic alerts, and warnings issued by the India Meteorological Department (IMD). Thanks to the weather monitoring satellites, today we can track cyclones and predict their path, helping us reduce their impact on life and property. Several national and international organisations work together to monitor cyclone-related disasters. If you live in a cyclone-prone area, keep an emergency kit ready with essential items. During a cyclone, quickly move to a nearby designated cyclone shelter.

Let us wrap up!

- **Warm air rises, creating a low-pressure area.**
- **Cool air rushes to occupy the low-pressure area.**
- **Warm air rises, cools, and the water vapour condenses to form clouds.**
- **Bigger water drops in the clouds fall to the ground as rain, hail, or snow.**
- **Positive and negative charges are created in the clouds by strong winds blowing upwards and downwards.**
- **When positive and negative charges meet, they cause lightning. Lightning may occur within a cloud, between clouds, or between a cloud and the ground.**
- **Under certain weather conditions, storms may develop into cyclones.**

## Snapshots

- Pressure is defined as force per unit area.
- The SI unit of pressure is newton/metre$^2$ ($N/m^2$) and is also called pascal denoted by Pa.
- Liquids and gases exert pressure on the walls of a container.
- The pressure exerted by the air around us is known as atmospheric pressure.
- Differences in air pressure cause winds to blow.
- Warm air rises, creating a low-pressure area. Cooler air from surrounding higher-pressure regions moves in to take its place.
- Important requirements for the formation of thunderstorms are moisture and strong winds.
- Strong winds moving upwards and downwards facilitate rubbing of ice particles with water droplets, causing electric charges to develop in clouds.
- Collision of electric charges within a clouds, or between clouds, or between a cloud and the ground causes lightning.
- Lightning strikes can cause destruction to life and property.
- Lightning conductors protect buildings from the effects of lightning.
- The India Meteorological Department (IMD) constantly monitors cyclones and thunderstorms in India.



## Keep the curiosity alive

1. Choose the correct statement.

(i) Look at Fig. 6.21 carefully. Vessel R is filled with water. When pouring of water is stopped, the level of water will be ____________.

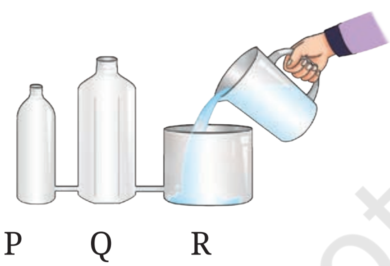


*Fig. 6.21*

(a) the highest in vessel P
(b) the highest in vessel Q
(c) the highest in vessel R
(d) equal in all three vessels

(ii) A rubber sucker (M) is pressed on a flat smooth surface and an identical sucker (N) is pressed on a rough surface:

(a) Both M and N will stick to their surfaces.
(b) Both M and N will not stick to their surfaces.
(c) M will stick but N will not stick.
(d) M will not stick but N will stick.

(iii) A water tank is placed on the roof of a building at a height 'H'. To get water with more pressure on the ground floor, one has to

(a) increase the height 'H' at which the tank is placed.

(b) decrease the height 'H' at which the tank is placed.

(c) replace the tank with another tank of the same height that can hold more water.

(d) replace the tank with another tank of the same height that can hold less water.

(iv) Two vessels, A and B contain water up to the same level as shown in Fig. 6.22. $P_A$ and $P_B$ is the pressure at the bottom of the vessels. $F_A$ and $F_B$ is the force exerted by the water at the bottom of the vessels A and B.

(a) $P_A = P_B$, $F_A = F_B$

(b) $P_A = P_B$, $F_A < F_B$

(c) $P_A < P_B$, $F_A = F_B$

(d) $P_A > P_B$, $F_A > F_B$

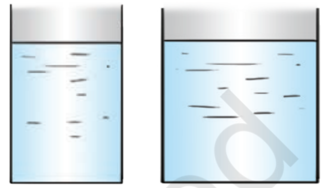


*Fig. 6.22*

2. State whether the following statements are True [T] or False [F].

(i) Air flows from a region of higher pressure to a region of lower pressure. [ ]

(ii) Liquids exert pressure only at the bottom of a container. [ ]

(iii) Weather is stormy at the eye of a cyclone. [ ]

(iv) During a thunderstorm, it is safer to be in a car. [ ]


*Fig. 6.23 (a)*

3. Fig. 6.23 a shows a boy lying horizontally, and Fig. 6.23 b shows the boy standing vertically on a loose sand bed. In which case does the boy sink more in sand? Give reasons.

4. An elephant stands on four feet. If the area covered by one foot is 0.25 $m^2$, calculate the pressure exerted by the elephant on the ground if its weight is 20000 N.


*Fig. 6.23 (b)*



**Prepare some questions based on your learnings so far ...**

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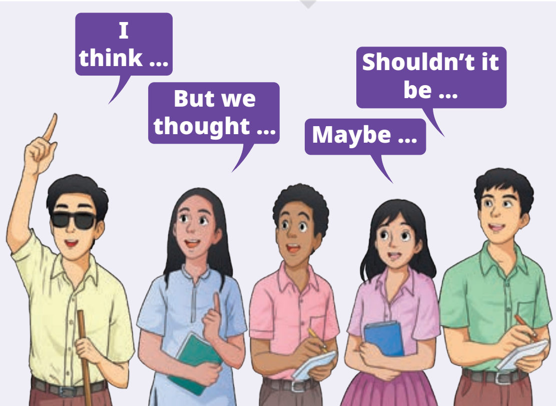
5. There are two boats, A and B. Boat A has a base area of 7 $m^2$, and 5 persons are seated in it. Boat B has a base area of 3.5 $m^2$, and 3 persons are seating in it. If each person has a weight of 700 N, find out which boat will experience more pressure on its base and by how much?
6. Would lightning occur if air and clouds were good conductors of electricity? Give reasons for your answer.

*Fig. 6.24*

7. What will happen to the two identical balloons A and B as shown in Fig. 6.24 when water is filled into the bottle up to a certain height. Will both the balloons bulge? If yes, will they bulge equally? Explain your answer.
8. Explain how a storm becomes a cyclone.
9. Fig. 6.25 shows trees along the sea coast in a summer afternoon. Identify which side is land— A or B. Explain your answer.


*Fig. 6.25*

10. Describe an activity to show that air flows from a region of high pressure to a region of low pressure.
11. What is a thunderstorm? Explain the process of its formation.
12. Explain the process that causes lightning.
13. Explain why holes are made in banners and hoardings.




**Reflect on the questions framed by your friends and try to answer ...**

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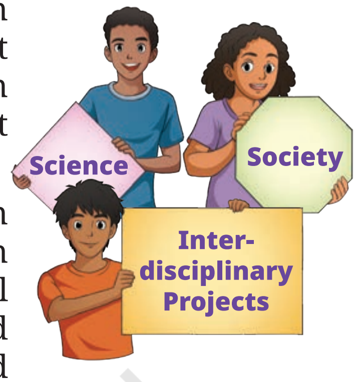
## Discover, design, and debate




- Hold a strip of paper, 18 cm long and 2 cm wide, between your thumb and forefinger so that it hangs freely. Predict what you will observe if you blow over the paper. Perform the activity now. Note down your observations and interpret your results.
- List three major cyclones which have occured in India in the last 20 years. List two major destruction caused by each of the cyclones. What measures were taken by the local government and communities to reduce the loss of life and destruction of property? Mention two suggestions you would like to propose to the local government.
- Collect data on the strength of thunderstorms for various regions of India. Compare your findings and identify which regions are more prone to thunderstorms. Can you give reasons for your findings?

# Particulate Nature of Matter

7

0877CH07



## Probe and ponder

- Why is it possible to pile up stones or sand, but not a liquid like water?
- Why does water take the shape of folded hands but lose that shape when released?
- We cannot see air, so how does it add weight to an inflated balloon?
- Is the air we breathe today the same that existed thousands of years ago?
- Share your questions

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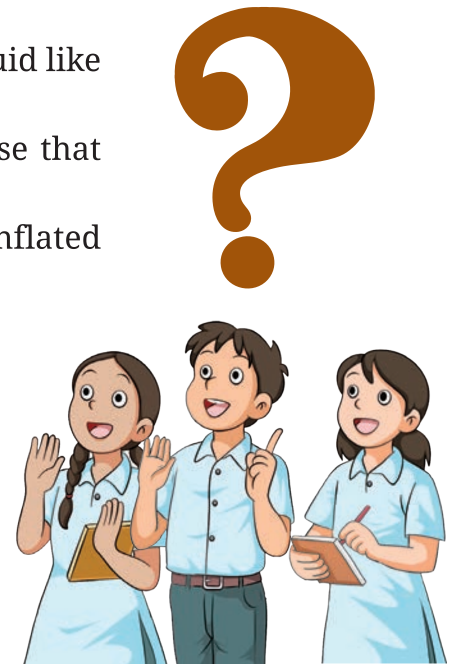


You might have collected pebbles and stones from the sand while playing on a riverbank or a beach. Where do these pebbles, stones, and sand come from?

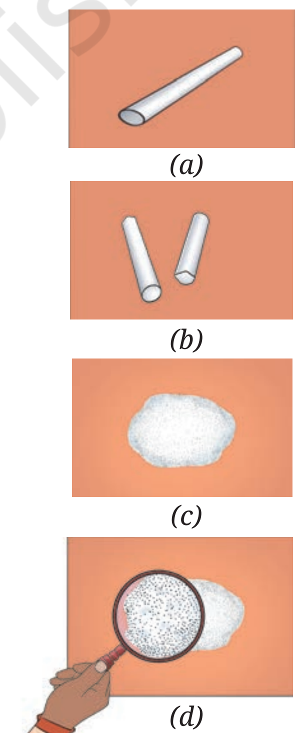
In the mountains, rocks gradually break down due to erosion. Rivers flowing through these regions carry along the eroded rock pieces. As the rivers flow, they continue to break down the rocks further into pebbles, stones, sand; and transport large quantities of them to the plains.

The bigger rocks are eventually broken down into finer grains of sand and clay. Is this grain the smallest unit of a bigger rock or can these grains of sand and clay be broken down further? Let us find out!

## 7.1 What Is Matter Composed of?

### Activity 7.1: Let us explore

- Take a stick of chalk (Fig. 7.1a) and break it into two pieces (Fig. 7.1b).
- Continue breaking the chalk till it becomes difficult to break it further by hand.
- Grind the small pieces of chalk thus obtained (Fig. 7.1c) using mortar and pestle.
- **Observe** the fine powder of chalk with a magnifying glass (Fig. 7.1d).
- What do you observe?
- Each tiny grain you observe is still a speck of chalk.



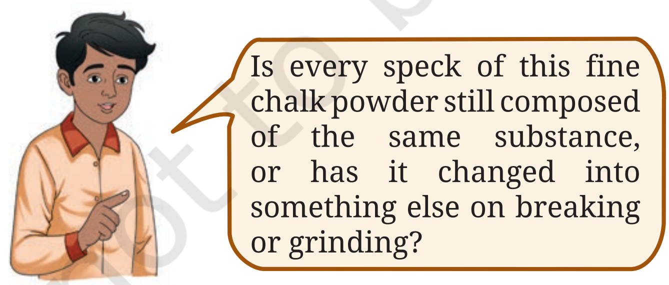
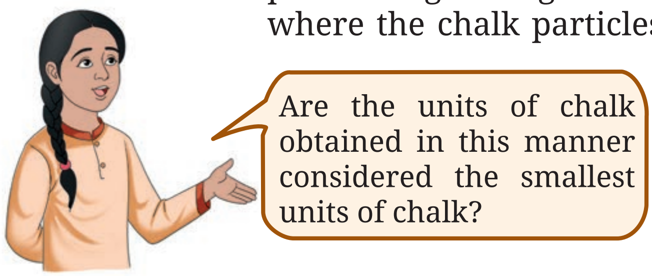



Fig. 7.1: (a) A stick of chalk; (b) The chalk stick broken into two pieces; (c) A piece of chalk ground into fine powder; (d) A close-up view of chalk powder under a magnifying glass

Recall *Curiosity*, Grade 7 chapter 'Changes Around Us: Physical and Chemical'— is grinding chalk a physical change or a chemical change? You learnt that the chalk does not change into a new substance on grinding. It is a physical change in which only the size of each speck of chalk has reduced further.

These specks of chalk powder can be broken further into smaller particles by further grinding. Let us imagine that this process of grinding continues. Eventually, we would reach a stage where the chalk particles cannot be broken down any further. The tiny units obtained at this stage are the basic building blocks that the chalk was made up of.




This means that one whole piece of chalk was made up of a large number of smaller units. These units are called constituent particles of chalk. A **constituent particle** is the basic unit that makes up a larger piece of a substance or material. Just like chalk, the grains of sand and clay are not the smallest units of bigger rocks. These are also made up of a large number of their constituent particles.

Let us **explore** further!

Recall the dissolution of sugar into water to form a solution. What happens to sugar when it is dissolved in water?

## Activity 7.2: Let us perform

**Safety first**

Perform the activity under the supervision of a teacher or an adult. Never eat or drink anything unless asked to.

- Fill a glass tumbler with drinking water.
- Put two teaspoons of sugar into it.
- Do not stir the water. Taste a small spoonful of water from the top layer of the glass.

Does the water taste sweet?

- Now, stir the water until the sugar dissolves completely (Fig. 7.2).
- Again taste a spoonful of water from the top layer.

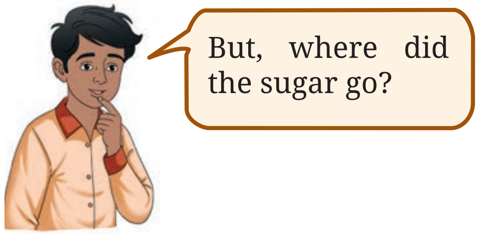
What difference in taste do you notice? Does it taste sweet?

Since the top layer of water tastes sweet after dissolving sugar, it must be present in the solution. Do you observe any sugar particles in the solution?

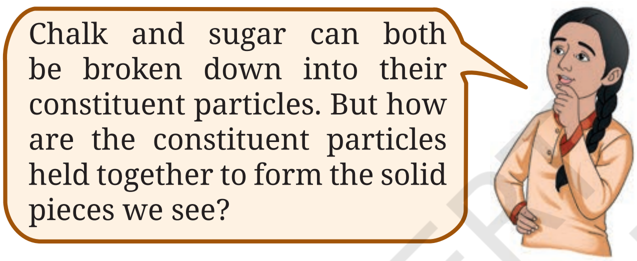
Sugar particles can no longer be observed but their presence can be sensed by taste. When sugar dissolves in water, it breaks up into its constituent particles which cannot be broken down further. Each tiny grain of sugar is made up of millions and millions of such constituent particles.

*Fig. 7.2: Dissolving sugar in water*

Activities 7.1 and 7.2 support the idea that matter is composed of a large number of extremely small particles. These particles are so small that they cannot be seen even through an ordinary microscope.




The tiny sugar particles separate and occupy the available spaces between the water particles. These spaces between the particles are known as **interparticle spaces**.




## 7.2 What Decides Different States of Matter?

The constituent particles of matter are held together through forces which are attractive in nature. These forces are called **interparticle attractions**. The strength of these attractions depends on the nature of the substance and the interparticle distance. Even a slight increase in the distance decreases the interparticle forces drastically. The strength of these forces ultimately decides the physical state of the substances.

### Our scientific heritage

Do you know that since ancient times, people have been thinking about how far things could be broken down and what is matter made up of?

Acharya Kanad, an ancient Indian philosopher, first spoke about the idea of a *Parmanu* (atom). He believed that matter is made up of tiny, indivisible eternal particles called *Parmanu*. This idea was written in his work called *Vaisheshika Sutras*.

Let us explore how these attractions vary in different states.

### 7.2.1 Solid state

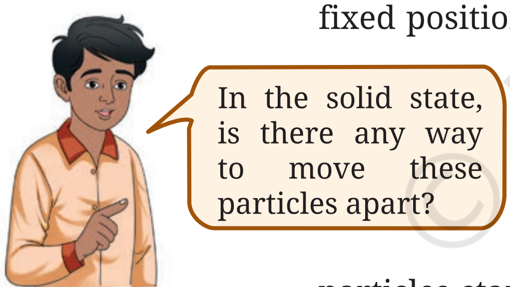
How are constituent particles held together in **solids**?

## Activity 7.3 : Let us find out

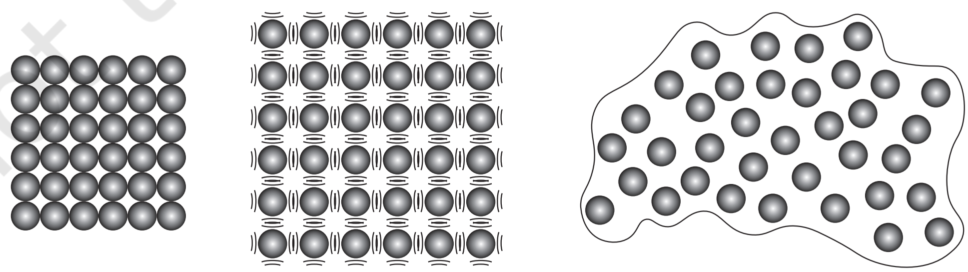

*Fig. 7.3: Some solid objects*

- **Collect** a few solid objects, such as a piece of iron or an iron nail, a piece of rock salt, a stone, a piece of wood, a key, and a piece of aluminium (Fig. 7.3).
- Observe their shapes and sizes.
- Try hammering them.
- In which of the above six objects do you think particles are strongly held together?

You must have noticed that all these objects are solids. They have a **definite shape** and **volume**. This is due to the fact that in solids, the particles are tightly packed and the interparticle attractions are very strong. These strong forces of attraction hold the particles in fixed positions, preventing them from moving freely (Fig. 7.4a). The particles can only move to and fro about their positions (vibrate or oscillate) but cannot move past each other.

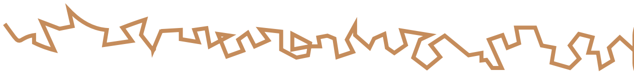



When solids are heated, their particles vibrate more vigorously (Fig. 7.4b). A stage is reached when these vibrations become so vigorous that the particles start leaving their position. The interparticle forces of attraction get weakened and the solid gets converted into the liquid state (Fig. 7.4c). The temperature at which this happens is the melting point of the solid.



*(a) Solid* *(b) Particles with increased vibrations* *(c) Liquid*

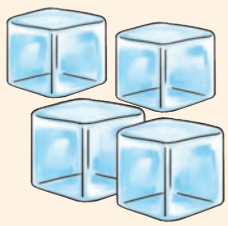
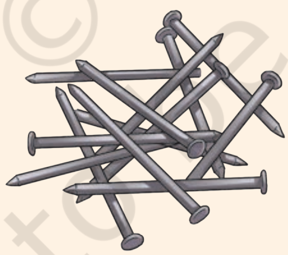
*Fig. 7.4: Magnified schematic pictures of melting of a solid*



The minimum temperature at which a solid melts to become a liquid at the atmospheric pressure is called its **melting point**. Generally, in a liquid state, particles are somewhat farther away from each other as compared to those in the solid state (ice is an exception—its particles are farther apart than those in water).

Some solids have weak interparticle forces of attraction, so their melting points are low. While others have strong attractive forces and have high melting points. Some examples of solids and their melting points are shown in Table 7.1.

**Table 7.1: Melting points of some solids**

| S.No. | Material | Melting point |
|---|---|---|
| 1. | Ice  | 0 °C |
| 2. | Urea  | 133 °C |
| 3. | Iron  | 1538 °C |

### 7.2.2 Liquid state

## Activity 7.4: Let us try and find out

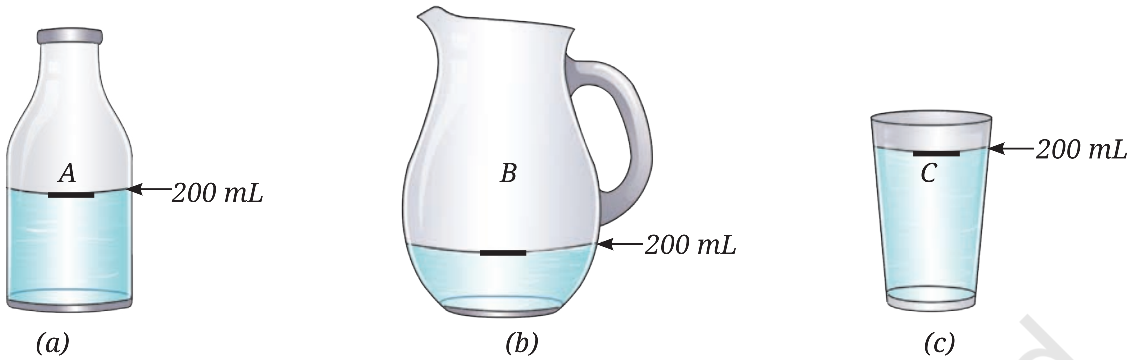



*Fig. 7.5: Water placed in containers of different shapes*

- Take three clean and dry containers of different shapes. Label them A, B, and C (Fig. 7.5).
- Mark the 200 mL level in each container using a marker or by pasting a thin strip of paper.
- Fill Container A with water up to the marked level.
- Carefully transfer the water from Container A to Container B without spilling, and observe the shape and level of the water.
- Now, transfer the same water from Container B to Container C, carefully, and observe the shape and its level again.

You will notice that the water takes the shape of the container into which it is poured. So, we can say that the **liquids** do not have a fixed shape and take the shape of the container they are kept in. This happens because the particles of liquids are free to move. In all three containers, the water level remains at 200 mL and no change in volume is observed. Hence, we can say that liquids have a **definite volume**. However, if a container is not clean, some water may stick to its walls, causing the water level in the next container to be slightly less than 200 mL after pouring.

*Fig. 7.6: Moving finger through water*

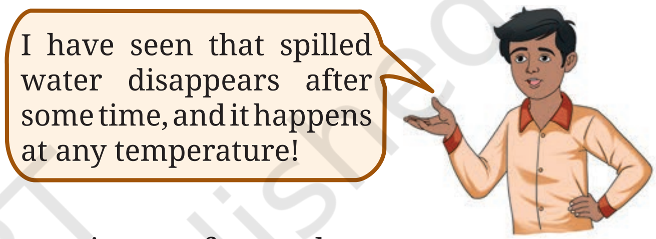
Activity 7.4 shows that the particles of liquids can move freely, but only within a limited space. Therefore, we can **infer** that liquids have no fixed shape but have a fixed volume.

Let us now **compare** interparticle forces of attraction in liquids and solids. Take some water in a shallow vessel and try to move your finger through it (Fig. 7.6).

Are you able to move your finger through the water?

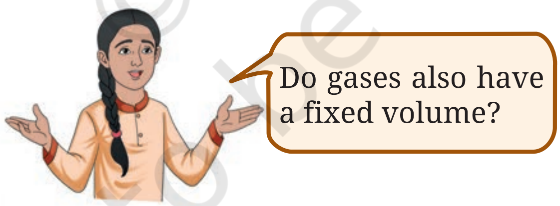
You can move your finger through water without breaking or cutting it permanently, which cannot be done in the case of solids. When you try this, you are temporarily displacing water. As soon as you remove your finger, the position of the water is restored. We can say that in liquids, the interparticle attractions are slightly weaker than in solids, but still strong enough to keep the particles close together.

Recall *Curiosity*, Grade 6 chapter 'Temperature and Its Measurement', where you observed the temperature of boiling water (liquid). When a liquid is heated, a stage comes when it starts boiling. The temperature at which a liquid boils and turns into vapour at atmospheric pressure is called its **boiling point**. The movement of particles becomes so vigorous that they move apart from each other, resulting in a decrease in the interparticle forces of attraction. Eventually, the constituent particles can escape from the liquid state. The liquid is converted into vapour or the gaseous state.




At the boiling point, the formation of vapour is very fast and occurs not only at the surface but also within the liquid. This process is observed as bubble formation in the liquid. However, vapour formation occurs at all temperatures, even below the boiling point, though slowly and only at the surface. This slower process is known as evaporation— about which you have learnt in earlier grades.

### 7.2.3 Gaseous state

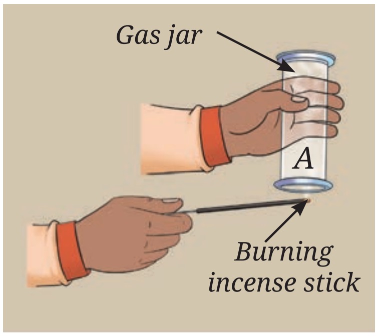



## Activity 7.5: Let us investigate

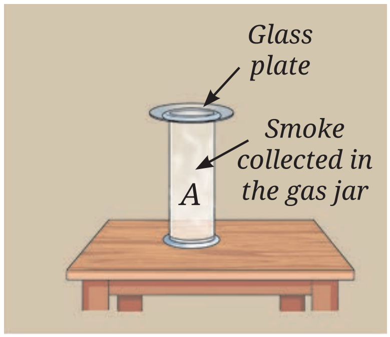
**Safety first**

Be careful while burning an incense stick.

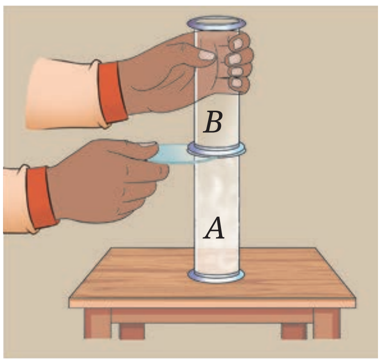
- Take two transparent gas jars or glass tumblers and mark them A and B.
- Create some smoke by burning an incense stick.
- Hold the Gas Jar A upside down over the smoke (Fig. 7.7a).
- The gas jar should trap the smoke inside.
- Turn it over and cover it with a glass plate (Fig. 7.7b).
- Hold another Gas Jar B upside down and gently place it over the glass plate covering the Gas Jar A.



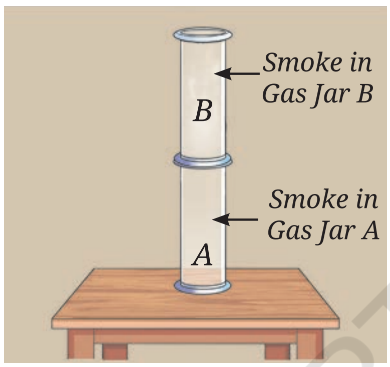

(a) Collecting smoke




(b) Covering the gas jar with a glass plate




(c) Placing the Gas Jar B and removing the glass plate




(d) Spreading the smoke

*Fig. 7.7: Smoke spreads freely inside the gas jars*

- Remove the glass plate slowly and ensure that both gas jars are close enough and there is no gap for smoke to escape (Fig. 7.7c).
- Observe how the smoke spreads inside the Gas Jar B.
- The smoke fills the entire space in the Gas Jar B, indicating that gases do not have a fixed volume and tend to occupy the entire available space (Fig. 7.7d). Like liquids, they also acquire the shape of the vessel they are in.

This illustrates that the particles in gases move freely in all directions and the interparticle attractions are negligible. As a result, gases do not have a fixed shape or volume.

In this activity, smoke is used to represent the gaseous state. The tiny particles of smoke suspended in the air are constantly hit by invisible particles of gases, and their movement helps us observe the motion of gas particles.

This activity can also be demonstrated by using iodine vapour instead of smoke from incense sticks.

**Safety first**

Be careful while using solid iodine. Vapours of iodine can cause irritation.

Iodine vapour can be obtained by placing some solid iodine in a closed gas jar for some time, as shown in Fig. 7.8.

Both liquids and gases flow and do not retain a fixed shape. These properties distinguish them from solids and **classify** them as **fluids**.

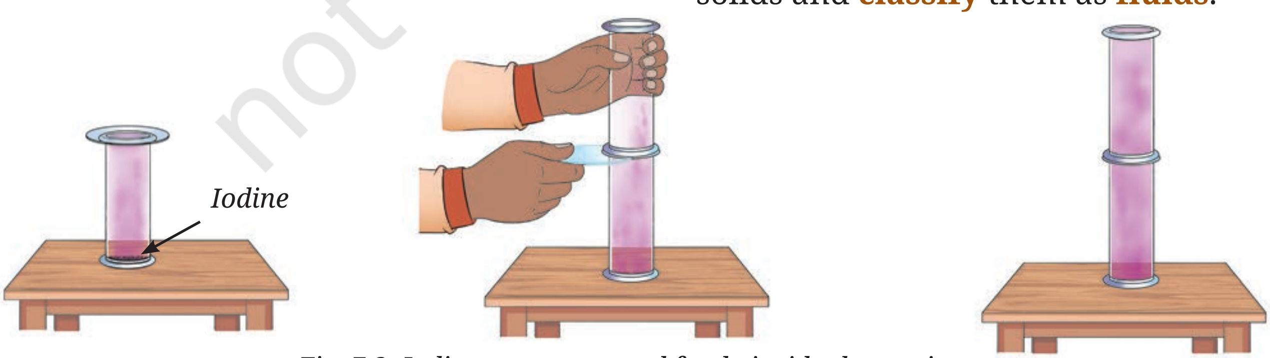



*Fig. 7.8: Iodine vapour spread freely inside the gas jar*

## 7.3 How Does the Interparticle Spacing Differ in the Three States of Matter?

What role does the interparticle spacing play in determining the properties of each state (solid, liquid, and gas)?

Let us **perform** the following activities to find answers to these questions.

### Activity 7.6: Let us experiment

- Take a syringe without a needle. Pull the plunger of the syringe outwards in a fully extended position (Fig. 7.9a).
- Place your thumb over the open end of the syringe to prevent the air present inside the syringe from escaping (Fig. 7.9b).
- Push the plunger slowly and steadily inward (Fig. 7.9c).

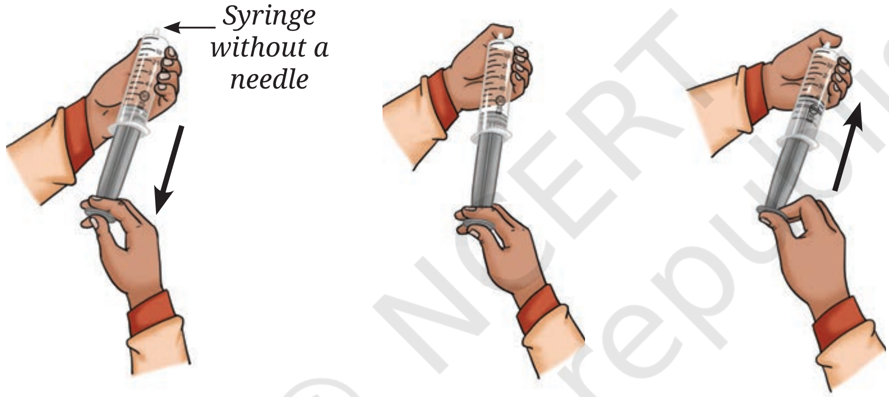



*Fig. 7.9: The syringe piston in different positions*



- What do you observe?

As you do this, you will notice that the volume of air inside the syringe decreases.

What can we say about the behaviour of gas in the syringe?

When you compress the air by pushing the plunger, the particles are forced to come closer. This shows that the gas particles have a lot of space between them in their natural state, and this space can be reduced by applying external pressure.

If you stop pushing the plunger, the gas particles spread, and the plunger moves back to its original position.

Repeat this activity using water and observe.

You would observe that water is practically incompressible.

Let us perform another activity to learn about the interparticle spaces in liquids.

## Activity 7.7: Let us observe

- Take a glass vessel, fill it about half with water, and mark the level of water A (Fig. 7.10a).
- Add two teaspoons of sugar into it.
- Mark the new water level on the glass vessel B (Fig. 7.10b).
- Stir the water with a glass rod to dissolve the sugar (Fig. 7.10c).
- **Predict** whether the water level will increase or decrease with respect to the mark B.
- Mark this water level again as C (Fig. 7.10d).

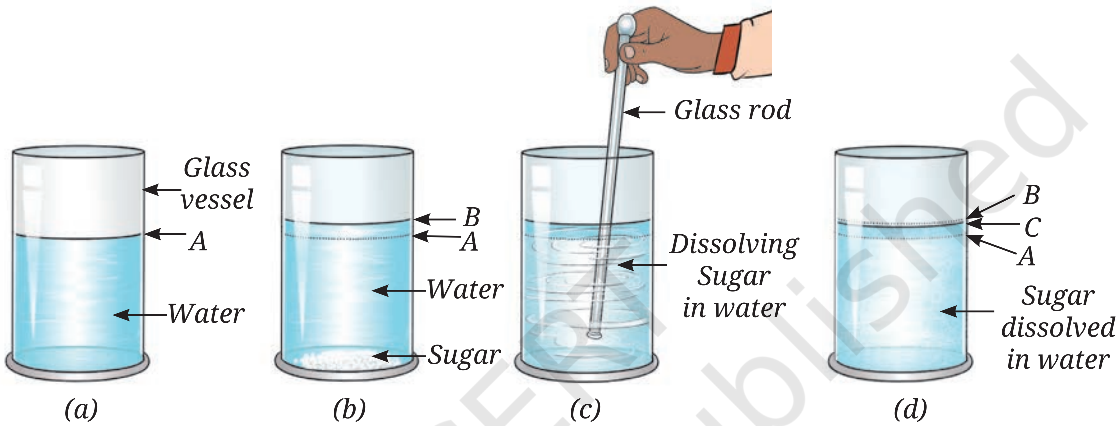



*Fig. 7.10: Variation in water levels*

What difference do you observe in the water levels?

You will observe that initially, when sugar is added, the level of water increases, but after dissolution, it may decrease to some extent. Since the volume of the solution is less than the sum of the volumes of water and sugar, it indicates that there is some space between the water particles. The particles of the dissolved substance occupy these spaces (Fig. 7.11).

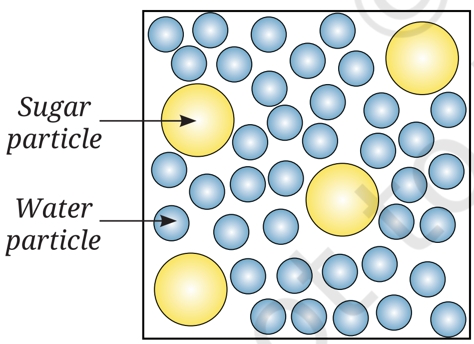
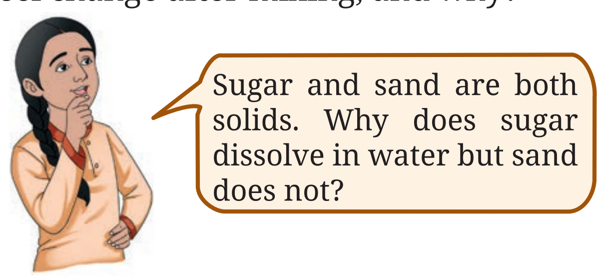



*Fig. 7.11: Magnified schematic picture of distribution of sugar particles in water*

Repeat the Activity 7.7 with some other soluble solids, such as common salt or glucose, and insoluble solids, like sand and stone pieces.

What do you observe in each case? Do the sand particles dissolve? Does the volume of water in the vessel change after mixing, and why?



Sand is a solid that does not dissolve in water. When added to water, the sand particles settle down and occupy some space in the container, causing the total volume to increase.

What do you think about the interparticle spacing in solids?

You learnt earlier that the constituent particles in solids are held together by strong forces of attraction. So, these particles do not move from one place to another and are closely packed. However, despite close packing, some space is left between the particles as shown in Fig. 7.12a. You might assume that the space between particles is filled with air, but this is not the case. They contain nothing at all. Fig. 7.12 summarises the packing of particles and the interparticle spacing in the three states of matter.

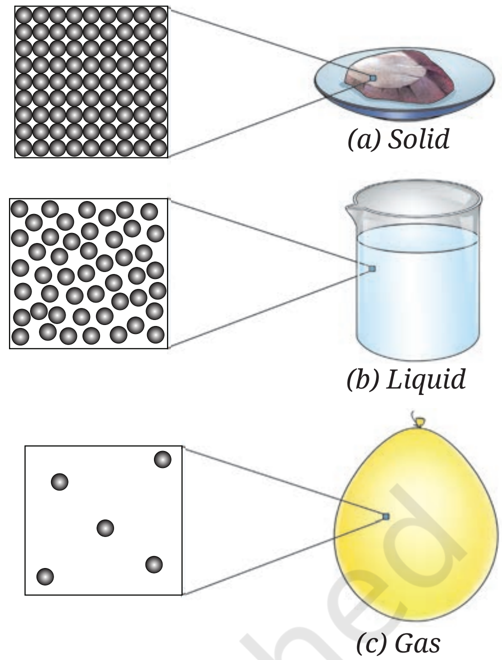



*Fig. 7.12: Magnified schematic pictures of interparticle spacing in the three states of matter*

## A step further

Often, we use the term 'particle' in different contexts. The meaning of this term changes with the context. For example, while talking about air pollution, the term Suspended Particulate Matter (SPM) is used. This term refers to the tiny dust particles suspended in air and not the constituent particles of matter which are extremely small as compared to the dust particles. In fact, even these tiny dust particles are also made up of a very large number of constituent particles, i.e, atoms and molecules.

## 7.4 How Particles Move in Different States of Matter?

Let us find out about the movement of particles in the three states of matter.

### Activity 7.8: Let us experiment

- Take a glass tumbler containing water and put a few grains of potassium permanganate into it.
- What do you observe?

**Safety first**

Do not touch potassium permanganate with your hands. Use a spoon or a spatula to handle it.

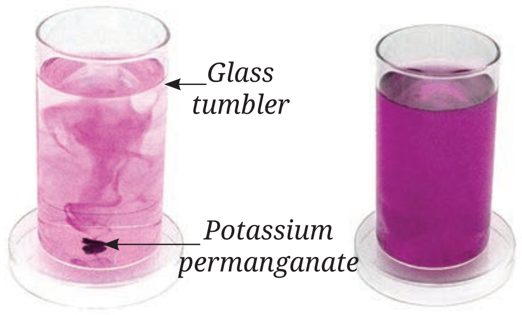



*Fig. 7.13: (a) Streaks of pink colour spreading out; (b) Uniform pink colour in glass tumbler*

- Initially, you will see some streaks of pink colour spreading out from the grain (Fig. 7.13a).
- With the passage of time, the entire bulk of water will acquire a uniform pink colour (Fig. 7.13b).
- Do you know why this happens?

This happens because the water particles are in constant motion. First they pull out the particles of potassium permanganate from its grain, and later they hit these particles so that they get spread throughout the liquid. In the case of many substances, the constituent particles are held together strongly that the water particles are unable to pull these out. Such substances, like sand, are insoluble in water.

## Think like a scientist

Try it yourself!

- Take three clean glass tumblers.
- Pour hot water in one of them, water at room temperature in the second and ice-cold water in the third.
- Drop a small grain of potassium permanganate into each of them.
- Watch carefully and compare. What do you observe?

Water particles move faster in hot water compared to water at room temperature, and even slower in ice-cold water. As a result, the potassium permanganate spreads the fastest in hot water, less quickly in water at room temperature, and the slowest in ice-cold water. Hence, the movement of particles increases when heat is provided.

Try to depict it by **drawing** a diagram.

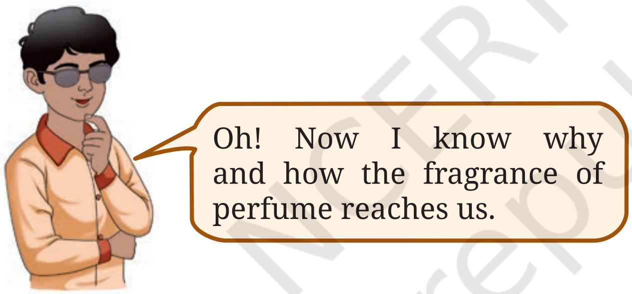
How can we **demonstrate** the movement of gas particles that cannot be seen with the naked eye?

## Activity 7.9: Let us find out

- Light an incense stick in one corner of the room (Fig. 7.14).
- Wait for a few minutes and observe.
- Do you notice the fragrance from a distance?

*Fig. 7.14: Burning of an incense stick*

When an incense stick is burnt in one corner of the room, initially, the fragrance is felt only around the incense stick. Shortly, you can smell the fragrance throughout the room. This happens because the particles of the fragrance spread, filling the entire room. This shows that the particles of air are moving constantly. The air particles hit the particles of the fragrance and help them spread throughout the room.




Can you share a few other real-life situations where you have experienced the movement of gas particles?

## Ever heard of ...

*Fig. 7.15: Particles of soap help in cleaning*

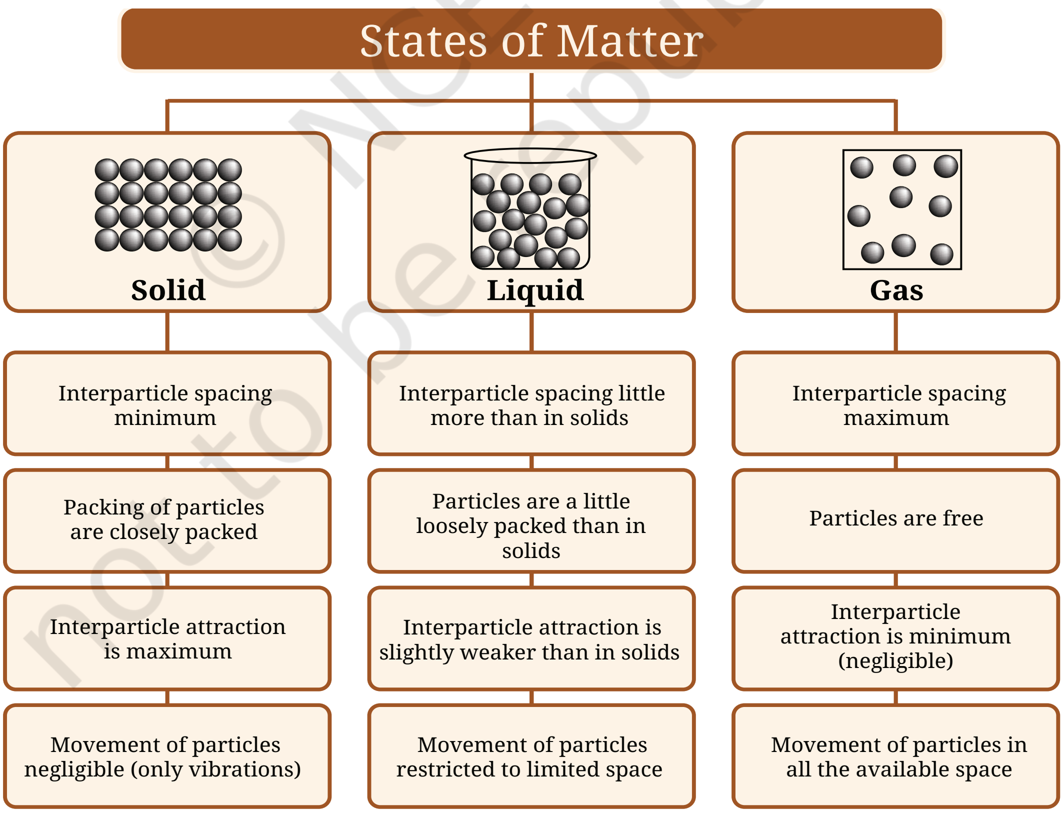
The particulate nature of matter plays a crucial role in many everyday processes. For example, when we wash clothes stained with oil using soap, numerous soap particles surround the oil particles on the fabric. One end of the soap particle attaches to the oil, and the other mixes with water, thus helping lift the oil off and wash it away (Fig. 7.15).

Based on our learnings from the chapter, we can say that matter is made up of small particles which are held together by the force of attraction. The strength of attractive forces between particles depends on the distance between them, which in turn depends on their thermal (heat) energy. Thus, it is the thermal energy of the particles that determines the physical state of matter. In the solid state, the thermal energy of particles is low, so they remain close to each other and experience strong interparticle attractive forces. This restricts their motion to only small vibrations.

At the melting point, the thermal energy is used to overcome the attractive forces between particles, allowing the solid to change into a liquid. At this stage, the particles can move away from their fixed positions. The interparticle distance increases slightly, reducing the strength of the attractive forces to a level that allows the particles to move around, though still within a limited space. In the gaseous state, the particles have enough energy to overcome the forces of attraction between them and move freely in all directions. You will learn more about these particles that constitute matter in higher grades.

Let us wrap up!

Particle nature of the three states of matter–



## Snapshots

- Matter is composed of extremely small particles.
- The particles are held together by interparticle forces of attractions.
- The interparticle attractions are the strongest in solids, a little weaker in liquids, and the weakest in gases.
- Solids have a fixed shape and size due to strong interparticle attraction, minimum interparticle space, and no free movement of the constituent particles.
- The interparticle attraction in liquids is slightly weaker than in solids, enabling the particles to move within a particular space and providing them with a little more interparticle spacing. Therefore, liquids have a definite volume but no fixed shape.
- The interparticle attractions in gases are negligible, making their particles completely free to move from one place to another and resulting in maximum interparticle space. Therefore, gases have no fixed shape and volume.

## Keep the curiosity alive

1. Choose the correct option.

   The primary difference between solids and liquids is that the constituent particles are:

   (i) closely packed in solids, while they are stationary in liquids.

   (ii) far apart in solids and have fixed position in liquids.

   (iii) always moving in solids and have fixed position in liquids.

   (iv) closely packed in solids and move past each other in liquids.

2. Which of the following statements are true? Correct the false statements.

   (i) Melting ice into water is an example of the transformation of a solid into a liquid.

   (ii) Melting process involves a decrease in interparticle attractions during the transformation.

   (iii) Solids have a fixed shape and a fixed volume.

   (iv) The interparticle interactions in solids are very strong, and the interparticle spaces are very small.



**Prepare some questions based on your learnings so far ...**

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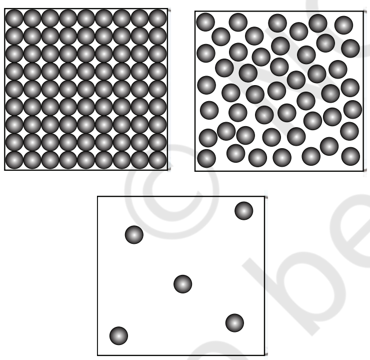
(v) When we heat camphor in one corner of a room, the fragrance reaches all corners of the room.

(vi) On heating, we are adding energy to the camphor, and the energy is released as a smell.

3. Choose the correct answer with justification. If we could remove all the constituent particles from a chair, what would happen?
   (i) Nothing will change.
   (ii) The chair will weigh less due to lost particles.
   (iii) Nothing of the chair will remain.
4. Why do gases mix easily, while solids do not?
5. When spilled on the table, milk in a glass tumbler, flows and spreads out, but the glass tumbler stays in the same shape. Justify this statement.
6. Represent diagrammatically the changes in the arrangement of particles as ice melts and transforms into water vapour.
7. Draw a picture representing particles present in the following:
   (i) Aluminium foil
   (ii) Glycerin
   (iii) Methane gas

*(a)*

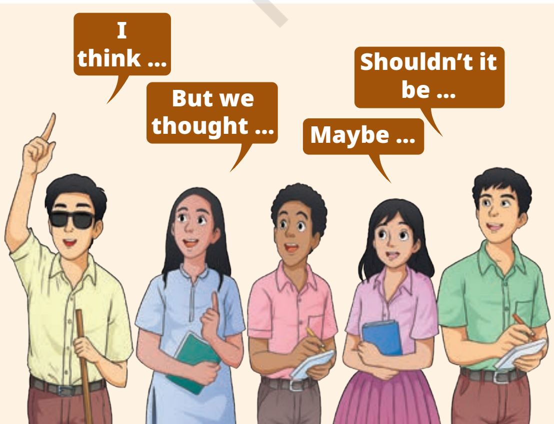


*(b)*

*Fig. 7.16*

8. Observe Fig. 7.16a which shows the image of a candle that was just extinguished after burning for some time. Identify the different states of wax in the figure and match them with Fig. 7.16b showing the arrangement of particles.
9. Why does the water in the ocean taste salty, even though the salt is not visible? Explain.
10. Grains of rice and rice flour take the shape of the container when placed in different jars. Are they solids or liquids? Explain.






**Reflect on the questions framed by your friends and try to answer ...**

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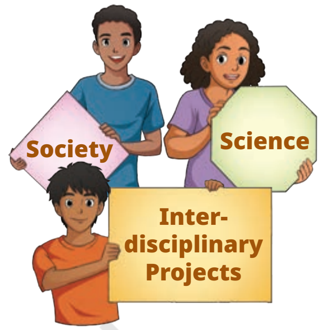
## Discover, design, and debate

- Fix a balloon over the neck of a bottle and put the bottle in hot water. Explore what will happen?
- Design and create simple models to represent particles of solids, liquids, and gases showing interparticle spacing using clay balls, beads, etc.
- Pretend to be particles of solids, liquids, and gases, at different temperatures—create and perform a role-play/ dance showing particles in motion.
- Debate in the class—'Gases can spread and fill all the available space'. Is this property of gases beneficial or harmful?




## A step further

The tiny particles that make up all matter are atoms and molecules. For example, iron is made up of atoms of iron, and gold is made up of atoms of gold. Atoms of many elements like hydrogen, oxygen, and sulfur are not able to exist independently. In such cases, a certain number of atoms of the same element combine to form a molecule. For example, two atoms of hydrogen combine and form a stable particle called a molecule of hydrogen. A water molecule is made up of two hydrogen atoms and one oxygen atom. You will learn about atoms and molecules in higher grades.

# Nature of Matter: Elements, Compounds, and Mixtures

8

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## Probe and ponder

- Which of the entities in the picture above consist of matter, and which of them do not?
- How can elements be combined to form a compound?
- How could the discovery of a compound that absorbs carbon dioxide from the air contribute to solving environmental challenges?
- Share your questions

  ______________________________

  ______________________________?

Have you ever wondered what the world around you is made of? Look around! The staircase you use, the air you breathe, the water in your bottle, the food in your lunch box, the clothes and shoes you wear, the book you read, the trees outside, the ball you play with and even the stick you carry—all of these are examples of **matter**, which you have learnt in earlier grades.

You have also learnt that all these things are made up of tiny particles. Most of the things around us are not made of just one substance; rather they are made up of two or more substances mixed together. Let us now understand how different substances come together to form mixtures.

## 8.1 What Are Mixtures?

*Fig. 8.1: Poha*

Have you ever wondered what makes your *poha* (Fig. 8.1) so delicious or how to make the perfect sprout salad? While these dishes may seem very different, they share something in common—they are both made by mixing several ingredients. We **observe** the mixing of substances in everyday life. Sugar dissolved in water is also a mixture, and so are soups and lemonade.

*Fig. 8.2: Sprout salad*

When two or more substances are mixed, where each substance retains its properties, it is called a **mixture**. The individual substances that make up a mixture are called its **components**. The components of a mixture do not react chemically with each other. In some mixtures, the components—like green gram, chickpeas, onion, and tomato in a sprout salad (Fig. 8.2), are easy to see. Such mixtures, where the different components are generally visible with the naked eye or with a magnifying device, are **non-uniform** in nature. Can you **identify** a few more examples of non-uniform mixtures around you?

On the other hand, some mixtures have components that cannot be seen separately even with the help of a microscope. For example, sugar and water particles cannot be seen separately in their mixture. Such types of mixtures, where the components are evenly distributed and cannot be distinguished, are **uniform** in nature (Fig. 8.3). Can you list a few uniform mixtures?

*Fig. 8.3: Uniform mixture of sugar and water*

## A step further

Do you know that stainless steel is also a mixture? Stainless steel contains iron, nickel, chromium, and a small amount of carbon. They are mixed so uniformly that the entire mixture appears the same throughout and one cannot see the individual substances. Such mixtures are known as alloys. Brass, a mixture of copper and zinc, and bronze, a mixture of copper and tin, are some other examples of alloys (Fig. 8.4).

*Fig. 8.4: Utensils made of stainless steel, brass, and bronze*

## Our scientific heritage

*Mishraloha* was the name given to the mixture of two or more metals that had properties distinct from its constituent metals. Ancient Indian texts, such as the *Charaka Samhita*, *Susruta Samhita*, *Rasaratna Samucchaya*, *Rasa Jala Nidhi*, etc., mention the use of alloys for medicinal purposes. For example, Bronze, also known as *Kamsya*, is an alloy made up of Copper (*Tamra*, 4 parts) and Tin (*Vanga*, 1 part), was used to improve digestion and boost immunity.

### 8.1.1 Is air a mixture?

In *Curiosity*, Grade 6, you learnt about air and its composition in the chapter 'Nature's Treasures'. Is air a mixture? What kind of mixture is it?

You have learnt that air is a uniform mixture of mainly nitrogen, oxygen, argon, carbon dioxide, and water vapour. Out of these, oxygen is required by most of the living beings to stay alive. It also helps in combustion. Nitrogen, which constitutes about 78% of the air, does not take part in combustion. We also learnt that air has water vapour in it. When warm air touches a cool surface, the water vapour turns into liquid water, forming tiny droplets. Recall the experiment where you tested the presence of carbon dioxide in the air that we exhale. Let us **confirm** the presence of carbon dioxide in the air.

## Activity 8.1: Let us experiment

- Take a glass tumbler and fill it half with water.
- Add a small amount of calcium oxide (quick lime) slowly to it.
- What do you observe?
- Calcium oxide reacts vigorously with water to form calcium hydroxide and releases heat.

**Safety first**

Perform this step carefully.

- Stir continuously to make a solution of calcium hydroxide. This solution is called lime water.
- Filter it and observe its colour.
- Leave this colourless solution in a petri dish for a few hours (Fig. 8.5a).
- Keep stirring the solution at regular intervals.
- What do you observe (Fig. 8.5b)?
- Does it turn milky?

Can you **explain** why the solution has turned milky?

You know that lime water turns milky when carbon dioxide reacts with calcium hydroxide to form calcium carbonate (insoluble tiny white particles) and water (Fig. 8.5). Since lime water turns milky when exposed to air, this activity **demonstrates** the presence of carbon dioxide in the air.

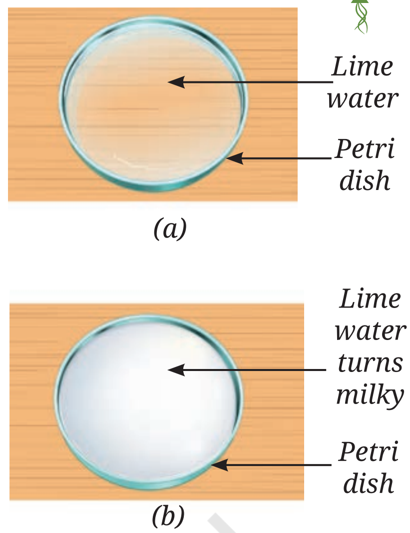


*Fig. 8.5: Lime water turns milky in the presence of carbon dioxide*

**Calcium hydroxide + Carbon dioxide ⟶ Calcium carbonate + Water**

Apart from gases, have you ever observed anything else present in the air? Have you ever noticed tiny shining particles moving in a beam of sunlight entering a dark room through a small opening? What are these particles?

## Activity 8.2: Let us explore

- Take a black sheet of paper. Ensure that it is free from any visible dust particles.
- Place the black sheet of paper undisturbed near an open window (Fig. 8.6a), or in the garden, for a few hours.
- What do you observe?

You may notice tiny particles settled on its surface. You may use a magnifying glass to **examine** the particles more closely (Fig. 8.6b).

This shows that dust particles are suspended in the air. They are not an integral part of the air and are considered pollutants. The nature and the number of dust particles in the air may vary from time to time and from place to place.

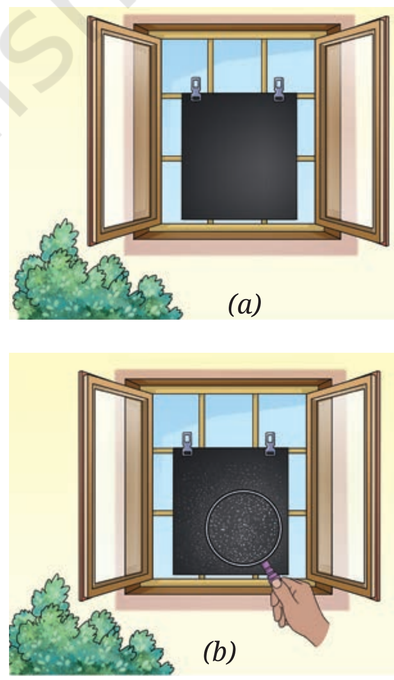


*Fig. 8.6: Black sheet of paper (a) with no dust particles; (b) with dust particles*

### A step further

The major pollutants present in the air are particulate matter (dust, soot) and gases like carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide. The **air quality index** (AQI) is a tool used to describe the air quality.

### 8.1.2 Types of mixtures

You know that the term 'mixture' in common usage refers to the mixing of two or more components. The components of a mixture may themselves be mixtures, as in *poha* and sprout salad, or pure substances like sugar or common salt dissolved in water. However, in science, all the components of a mixture must be pure substances only.

Mixtures could be of several types depending on the physical state of their components. Some mixtures with their examples are shown in Table 8.1. Complete the third column—

**Table 8.1: Different types of mixtures**

| S.No. | Mixture-type | Examples | Uniform or non-uniform |
|---|---|---|---|
| 1. | Gas and gas | Air | Uniform |
| 2. | Gas and liquid | Aerated water (soda water)<br>Oxygen dissolved in water | ....................<br>.................... |
| 3. | Solid and gas | Carbon particles in air | .................... |
| 4. | Liquid and liquid | Acetic acid in water (vinegar)<br>Oil and water | ....................<br>.................... |
| 5. | Solid and liquid | Sand and water<br>Seawater | ....................<br>.................... |
| 6. | Solid and solid | Baking powder (baking soda and tartaric acid)<br>Alloys | ....................<br>.................... |

You learnt in earlier grades about the separation of mixtures. It is done to separate the components of a mixture. The examples discussed were from everyday life, where separation is done to obtain the component of interest and other components are discarded. However, in science, the purpose of separating a mixture is to obtain pure substances.


*Fig. 8.7: Some consumable items*

## 8.2 What Are Pure Substances?

Have you ever noticed the word 'pure' written on the packs of some consumables, such as milk, ghee, and spices (Fig. 8.7)? The word 'pure' has slightly different meanings in common usage and in science.

In common usage, '**pure**' means unadulterated products. **Adulteration** is an illegal process of adding substances which are cheaper, or of a poor quality, to a product. This is usually done to increase the quantity or reduce the manufacturing cost. However, it deteriorates the quality of the product. It can also make the product hazardous to health.

In science, however, a pure substance is the one that has no other substance present in it. For a scientist, even these products that look pure can be considered **impure** if they are made of more than one substance.

A pure **substance** is a kind of matter that cannot be separated into other kinds of matter by any physical process. When a scientist says that something is pure, it means that the substance consists of the same type of particles.

### A step further

According to science, how would you **classify** milk, packed fruit juice, baking soda, sugar, and soil—as mixtures or pure substances?

## 8.3 What Are the Types of Pure Substances?

Recall the different states of water that you studied in *Curiosity*, Grade 6. What happened when water was cooled or heated? We observed that on cooling water gets converted into ice, and on boiling it gets converted into vapour. We can get back water up on heating ice or cooling water vapour. It shows that during these processes, the particles of water remain the same. Now, let us **perform** another activity in which we pass electricity through water and observe its effect.

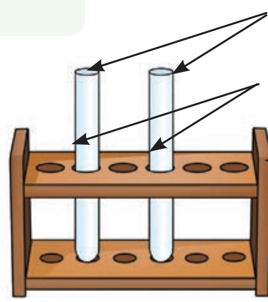


### Activity 8.3: Let us experiment (Demonstration activity)

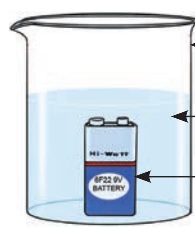
#### Safety first

This activity must be performed under the supervision of the teacher. Be careful while handling sulfuric acid. Do not use lithium-ion battery.

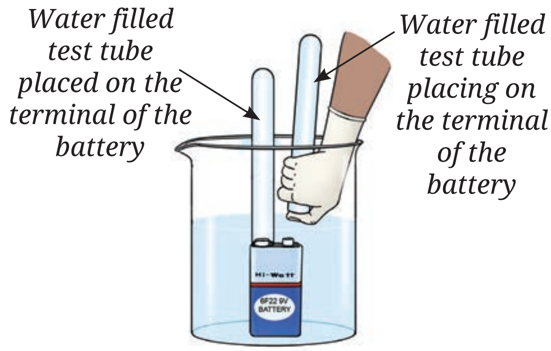
- Collect two small test tubes, a beaker or a glass tumbler, and a 9 V battery.
- Fill 2/3rd of the beaker with water and add a few drops of dilute sulfuric acid to it.
- Fill both the small test tubes completely with water taken from the beaker (Fig. 8.8a).
- Place a 9 V battery inside the beaker (Fig. 8.8b).
- Without spilling the water, carefully place the water-filled test tubes on each of the terminals of the battery (Fig. 8.8c).



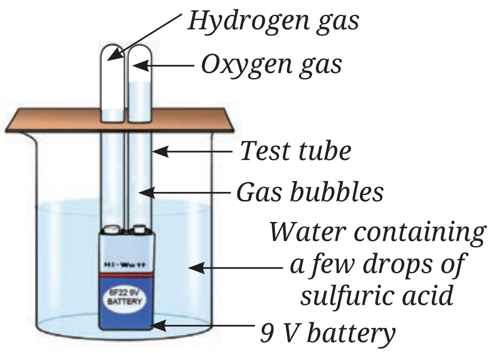

*(a) Test tubes filled with water*




*(b) 9 V battery placed inside the beaker containing water*



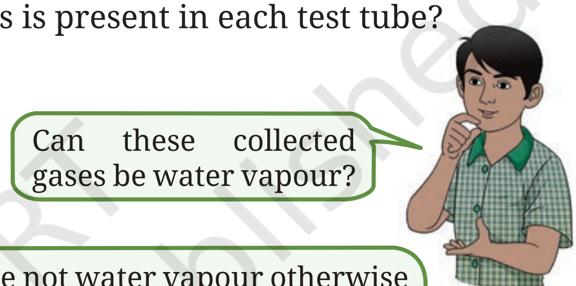

(c) Water filled test tubes placing over the terminals of the battery




(d) Gases collected in the test tubes

*Fig. 8.8: Passing electricity through water*

- Wait for a few minutes.
- Do you observe the formation of any gas bubbles at both the terminals inside the test tubes?
- Let it continue for 10–15 minutes.
- Observe the volume of gas collected in each test tube (Fig. 8.8d).
- Is the volume of the gas collected the same in both the test tubes?
- Remove these test tubes one-by-one carefully.
- Test these gases one-by-one by bringing a burning candle close to the mouth of the test tubes.
- What happens in each case?
- Which gas is present in each test tube?





**Safety first**

Perform gas testing with care. Maintain a safe distance from the set-up.

To test the gases present in the two test tubes, bring a burning candle near the mouth of each test tube. A pop sound can be heard from one, indicating the presence of hydrogen gas (Fig. 8.9a). In the other test tube, the flame of the burning candle will glow brighter, confirming the presence of oxygen gas (Fig. 8.9b).

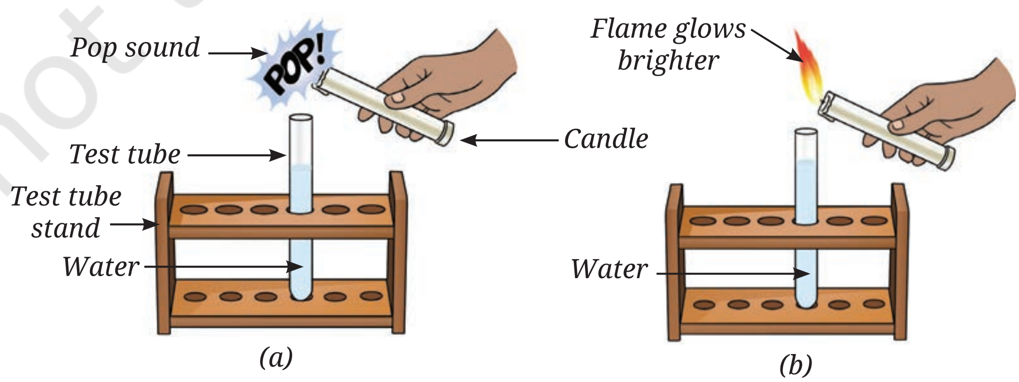



*Fig. 8.9: Testing the nature of gas (a) hydrogen; (b) oxygen*

From Activity 8.3, we can **infer** that water is composed of two different constituents—hydrogen and oxygen.

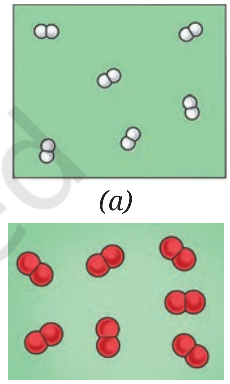
**Water ⟶ Hydrogen + Oxygen**

### Ever heard of ...

When electric current is passed through water, it breaks down into hydrogen and oxygen. Is this a chemical change or a physical change? Recall *Curiosity*, Grade 7, chapter 'Changes Around Us: Physical and Chemical'.

## 8.3.1 Elements

The two substances hydrogen and oxygen formed in Activity 8.3, are pure substances and are termed as **elements**. Each element is made up of identical particles called atoms. These particles are different from the particles of any other element. Elements are substances that cannot be further broken down into simpler substances. They are the building blocks of all matter. Some other examples of elements are gold, silver, sulfur, carbon, etc.



(a)

(b)

*Fig. 8.10: Depiction of molecules of (a) hydrogen; (b) oxygen*

### A step further

The atoms of most of the elements cannot exist independently. Two or more such atoms combine and form a stable particle of that element called a molecule. For example, two atoms of hydrogen combine to form one molecule of hydrogen. Similarly, two atoms of oxygen combine to form one molecule of oxygen (Fig. 8.10).

Elements can be classified into **metals** and **non-metals**. You have already studied that gold, silver, magnesium, iron, and aluminium are metals, whereas carbon, sulfur, hydrogen, and oxygen are non-metals. Isn't it interesting to know that some elements like silicon and boron have intermediate properties between those of metals and non-metals? They are called **metalloids**, about which you will learn in higher grades.

### A step further

- The number of elements known at present is 118, and most of them exist in a solid state.
- Eleven elements exist in a gaseous state at room temperature, all of which are non-metals like oxygen, helium, nitrogen, etc.
- Only two elements are liquid at room temperature—mercury, which is a metal and bromine, which is a non-metal.
- Although gallium and caesium are solid elements, they become liquid at a temperature around 30 °C (303 K) and turn into liquid.

## A step further

More than 45 different elements, like aluminium, copper, silicon, cobalt, lithium, gold, silver, etc., are used in manufacturing a mobile phone, including its screen, battery, and other components.

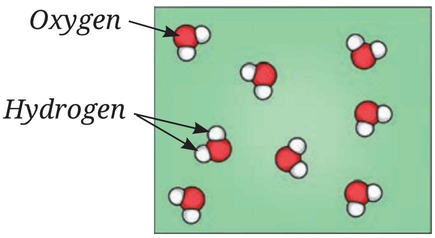
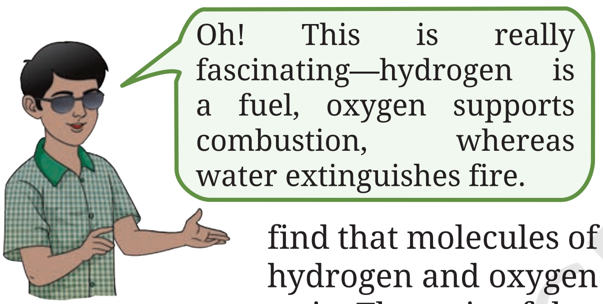



*Fig. 8.11: Depiction of molecules of water*

### 8.3.2 Compounds

Why cannot we separate hydrogen and oxygen present in water by physical means?

In water, the particles of hydrogen and oxygen are so tightly attached to each other that it is generally impossible to separate them apart using physical methods. That is why water is a compound. **Compounds** are formed when different elements combine in fixed ratios to form something entirely new. The properties of compounds are different from those of elements forming that compound. The constituent elements of a compound cannot be separated by any physical method. From Activity 8.3, we find that molecules of water are made of two different elements: hydrogen and oxygen (Fig. 8.11), combined chemically in a fixed ratio. The ratio of the number of atoms of hydrogen to oxygen in water has been found to be 2:1.




Are common salt and sugar elements or compounds? Let us find out.

Sodium, a soft metal, and chlorine, a hazardous gas, combine to form a harmless yet taste-enhancing substance that is essential for our lives. This substance is known as sodium chloride, which is made up of particles of sodium and chlorine in a 1:1 ratio. We learnt that dissolved sodium chloride (common salt) may be separated from water by the physical process of evaporation.

Is it possible to separate sodium chloride into its elements by physical processes?

Let us now explore if we can separate the elements in sugar!

## Activity 8.4: Let us experiment

**Safety first**

This activity must be performed in the presence of a teacher.

- Put a teaspoon of sugar in a boiling tube.
- Heat it gently as shown in Fig. 8.12a.
- What do you observe?

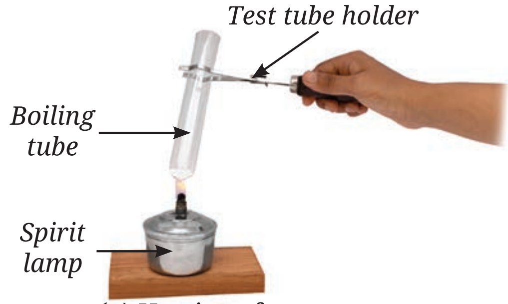
As you heat the sugar, it turns brown (Fig. 8.12b). Later, it begins to char, i.e., it turns blackish (Fig. 8.12c).

You will find small droplets of water inside the boiling tube near its open end. Where did this water come from? Was it in the dry sugar, or did it come by the condensation of water vapour in the air?

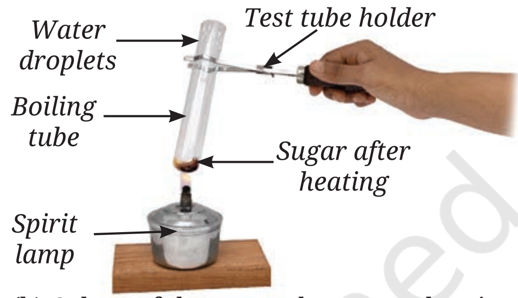
Since we are heating the tube, the water must have come from the dry sugar and not from the air. Can you **predict** what is left behind? Charcoal (carbon) is left behind in the boiling tube. You can scoop it out in a watch glass (Fig. 8.12c) and explore if it burns like coal.

Sugar decomposes on heating and gives carbon and water. As you know, water consists of hydrogen and oxygen. Hence, sugar cannot be an element. It may be stated that sugar is a chemical compound consisting of the elements carbon, hydrogen, and oxygen.

Let us explore more about compounds.



*(a) Heating of sugar*



*(b) Colour of the sugar changes on heating*

*(c) Charcoal placed on a watch glass*

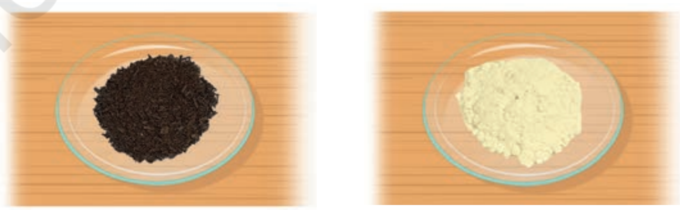
*Fig. 8.12: Heating sugar in a boiling tube*

## Activity 8.5: Let us experiment (Demonstration activity)

### Safety first

This activity may be demonstrated under the supervision of the teacher. It may be performed in a fume hood or a well-ventilated area. Do not inhale the gases.

- Take 5.6 grams of iron filings (Fig. 8.13a) and 3.2 grams of sulfur powder (Fig. 8.13b) on a watch glass. Observe them carefully.



(a) (b)

*Fig. 8.13: (a) Iron filings; (b) Sulfur powder*

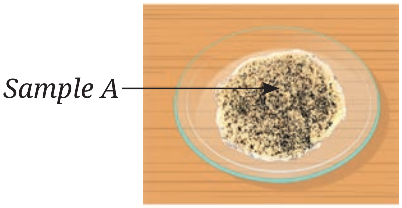



Fig. 8.14: A mixture of iron filings and sulfur powder

- Mix them thoroughly in a watch glass. Label this mixture as Sample A (Fig. 8.14).
- Observe it carefully.
- Is this a uniform or a non-uniform mixture? Can you still observe both iron and sulfur as separate substances?

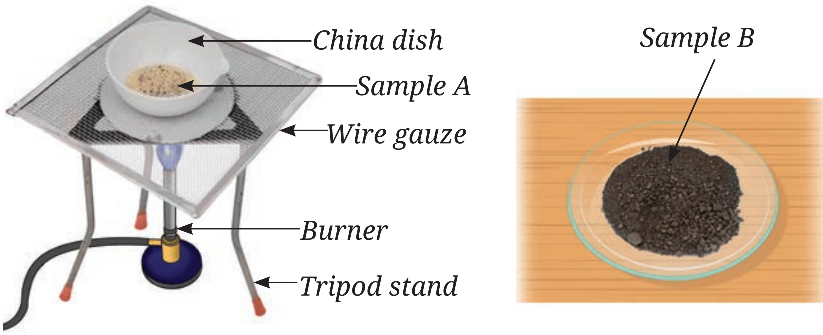
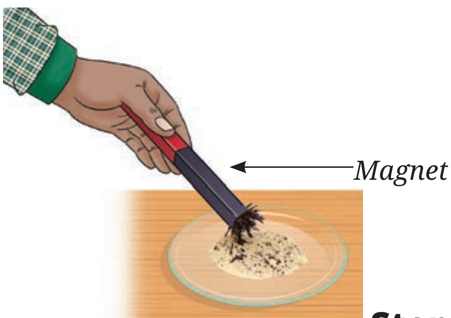
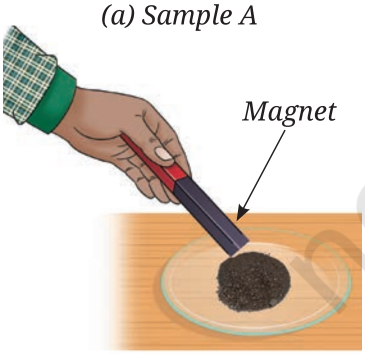



Fig. 8.15: (a) Heating Sample A; (b) Black mass

- Take half of Sample A in a china dish and gently heat it (Fig. 8.15a) with continuous stirring until a black mass is formed.
- Let the content of the china dish cool.
- Place this black mass in a mortar and grind it with the help of a pestle.
- Now, put it on another watch glass and label it as Sample B (Fig. 8.15b).
- Now, you have two samples— Sample A and Sample B (Fig. 8.16a and 8.16b). **Compare** both the Samples A and B step by step and **record** your observations in Table 8.2.




(a) Sample A




(b) Sample B

Fig. 8.17: Responses of Samples A and B to a magnet


Fig. 8.16: (a) Sample A; (b) Sample B

### Step 1 — Appearance

- Compare the appearance of Sample A and Sample B like colour and texture.

### Step 2 — Magnet test

- Take a magnet and move it over the Samples A (Fig. 8.17a) and B (Fig. 8.17b), one by one.
- What do you observe?

### Step 3 — Gas test

- Take a small amount of Sample A in a test tube and add a few drops of dilute hydrochloric acid (Fig. 8.18a).

**Safety first**

Be careful while handling hydrochloric acid.


*(a) Sample A* *(b) Sample B*

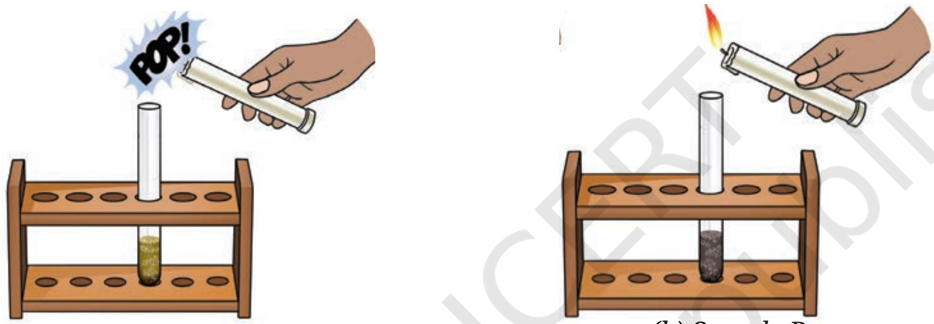
*Fig. 8.18: Samples A and B in dilute hydrochloric acid*

*Fig. 8.19: Correct way to waft the fumes of an evolved gas*

- What do you observe?
- Gently smell the evolved gas by wafting it towards your nose (Fig. 8.19).
- Test the evolved gas by bringing a burning splinter or a lighted candle near the mouth of the test tube (Fig. 8.20a).

**Safety first**

Never smell anything directly.




*(a) Sample A* *(b) Sample B*

*Fig. 8.20: Testing gases*

- What do you observe?
- Repeat the above steps with Sample B as well (Fig. 8.18b and 8.20b).

**Table 8.2: Comparison of Samples A and B**

| S.No. | Experiment | Observations | |
|---|---|---|---|
| | | Sample A | Sample B |
| 1. | Appearance<br>(i) Colour<br>(ii) Texture | | |
| 2. | Magnet test | | |
| 3. | Gas test<br>(i) Odour<br>(ii) Burning | | |

### Some discussion points

- Do the Samples, A and B look the same?
- Which sample exhibits magnetic properties?
- Can we separate the components of Samples A and B?
- On adding dilute hydrochloric acid, do gases evolve in both Samples A and B?
- In both the cases, do the gases smell the same or different?
- Also, **categorise** the substances used in this activity into mixtures, compounds, and elements.

*Sample A*

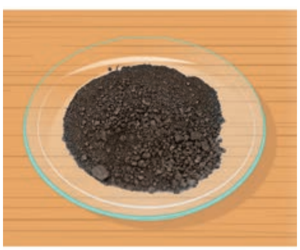
**Sample A**: We can say that Sample A is a mixture of the two elements—iron and sulfur. Its components retain their properties, and their black and yellow coloured particles can be seen. On bringing magnet near Sample A, the iron filings get attracted towards the magnet. Hence, iron and sulfur can be separated.

You might have observed that in Sample A, iron in the mixture reacts with dilute hydrochloric acid to form iron chloride and hydrogen gas. The gas is colourless, has no smell, and burns with a 'pop' sound.

The reaction can be represented as—

**Iron + Dilute Hydrochloric acid ⟶ Iron chloride + Hydrogen gas**

Sulfur on the other hand, is left as a yellow solid at the bottom of the test tube. This shows that sulfur does not react with hydrochloric acid.



*Sample B*

**Sample B**: The black mass obtained in Sample B is iron sulfide. We observe that the texture and the colour are the same throughout. It is formed by heating the two elements, iron and sulfur. It is not attracted by a magnet. The new substance has completely different properties, and iron and sulfur can no longer be separated. Hence, we can say that a compound has been formed. Can you explain now why the magnet has no effect on Sample B?

Also, Sample B, iron sulfide, reacts with dilute hydrochloric acid, to form iron chloride and hydrogen sulfide gas. The gas is colourless and has a rotten egg-like odour.

The reaction can be represented as—

**Iron sulfide + Dilute Hydrochloric acid ⟶ Iron chloride + Hydrogen sulfide**

## 8.4 How Do We Use Elements, Compounds, and Mixtures?

Elements, compounds, and mixtures are all around us. The air we breathe is a mixture of gases like oxygen, nitrogen, and carbon dioxide. Water, which is essential for life, is a compound made of elements, hydrogen and oxygen. Elements like iron and aluminium are used to construct bridges, buildings, and vehicles.

Understanding these concepts is not just about recognising what surrounds us; it is also the key to innovation. For instance, chemists study how elements combine to create compounds, enabling them to invent life-saving medicines and vaccines to fight diseases. This knowledge also helps in the creation of fertilisers thereby enhancing crop production that feeds the ever-increasing human population globally.

Engineers and material scientists rely on their understanding of compounds and mixtures to design materials with unique properties. For example, they have developed alloys like stainless steel, which is stronger and more durable than pure iron. Wood, steel, and concrete, which are used as building materials, are all mixtures.

You learnt that various metals are obtained from minerals. Let us learn about these minerals.

**A step further**

*Fig. 8.21*

An example of a 'wonder' material developed by material scientists is graphene aerogel. This is made from carbon and is said to be the lightest material on earth. It is so light that even grass can hold it (Fig. 8.21). It is highly porous and therefore, has a high absorbing capacity. For this reason, it can potentially be used as an environmental cleaner, for example, to clean up oil spills in both seas and on land. It is useful in fabricating energy-saving devices and special coatings for buildings.

## 8.5 What Are Minerals?

Most rocks are a mixture of **minerals**, which can be viewed with the eyes, or by using a magnifying glass or a microscope. Some of the minerals are called native minerals, which are pure elements and not compounds. These can be metals, such as gold, silver, copper, etc., or non-metals like sulfur, carbon, etc.

Most of the minerals are compounds made up of more than one element. Some common examples of minerals include quartz, calcite, mica, pyroxene, and olivine (Fig. 8.22). Many things that we use in our everyday life are made up of minerals or elements extracted from minerals. For example, cement is made from calcite, quartz, alumina, and iron oxide, which are minerals or are obtained from minerals. Talcum powder is made from the mineral talc.


*Fig. 8.22: Some minerals*

## Our scientific heritage

### Use of elements, compounds, and mixtures in Indian Art

The Dhokra art is an old craft from Bihar and Odisha that uses different metals to create beautiful figures inspired by nature (Fig. 8.23). The process begins with shaping a design in beeswax. This wax model is covered with clay to make a mould. After the clay hardens, the wax is melted out, leaving a hollow space. This space is then filled with molten brass or bronze which makes Dhokra art strong and gives it a shiny golden colour. The figures often show animals, people, and nature, reflecting tribal creativity and tradition.

*Fig. 8.23: Dhokra art*

Elements and compounds are the building blocks of matter—everything that has mass and takes up space. They make the materials we see and use every day. However, not everything around us is matter. Light, heat, electricity, and even thoughts and emotions are important parts of our world, but they are not made of matter. Understanding what matter is—and what it is not—helps us better understand the world around us.

## Snapshots

- A mixture consists two or more substances mixed together. These substances retain their individual properties and do not react chemically with each other.
- The individual substances that make up a mixture are called its components.
- A pure substance consists the same type of particles. All the constituent particles of that substance behave identically.
- Pure substance can be either an element or a compound.
- Elements are the simplest substances that cannot be broken down further into simpler substances. They are the building blocks of all matter.
- Substances which are composed of two or more elements combined chemically in a fixed ratio and have different properties from their constituent elements are called compounds.
- Minerals are natural, solid substances found on the Earth. They have a fixed chemical composition. Most often they are compounds but rarely, they can also be pure elements.

## Keep the curiosity alive

1. Consider the following reaction where two substances, A and B, combine to form a product C:

   $$A + B \longrightarrow C$$

   Assume that A and B cannot be broken down into simpler substances by chemical reactions. Based on this information, which of the following statements is correct?
   (i) A, B, and C are all compounds and only C has a fixed composition.
   (ii) C is a compound, and A and B have a fixed composition.
   (iii) A and B are compounds, and C has a fixed composition.
   (iv) A and B are elements, C is a compound, and has a fixed composition.
2. Assertion: Air is a mixture.

   Reason: A mixture is formed when two or more substances are mixed, without undergoing any chemical change.
   (i) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
   (ii) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.
   (iii) Assertion is true, but Reason is false.
   (iv) Assertion is false, but Reason is true.
3. Water, a compound, has different properties compared to those of the elements oxygen and hydrogen from which it is formed. Justify this statement.
4. In which of the following cases are all the examples correctly matched? Give reasons in support of your answers.
   (i) Elements — water, nitrogen, iron, air.
   (ii) Uniform mixtures— minerals, seawater, bronze, air.
   (iii) Pure substances— carbon dioxide, iron, oxygen, sugar.
   (iv) Non-uniform mixtures — air, sand, brass, muddy water.
5. Iron reacts with moist air to form iron oxide, and magnesium burns in oxygen to form magnesium oxide. Classify all the substances involved in the above reactions as elements, compounds or mixtures, with justification.



**Prepare some questions based on your learnings so far ...**

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6. Classify the following as elements, compounds, or mixtures in Table 8.3.

   Carbon dioxide, sand, seawater, magnesium oxide, muddy water, aluminium, gold, oxygen, rust, iron sulfide, glucose, air, water, fruit juice, nitrogen, sodium chloride, sulfur, hydrogen, baking soda.

**Table 8.3**

| Elements | Compounds | Mixtures |
|---|---|---|
| | | |

Identify pure substances amongst these and list them below.

**Pure substances**

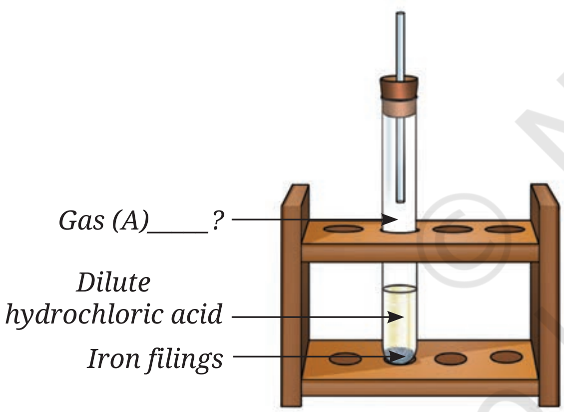
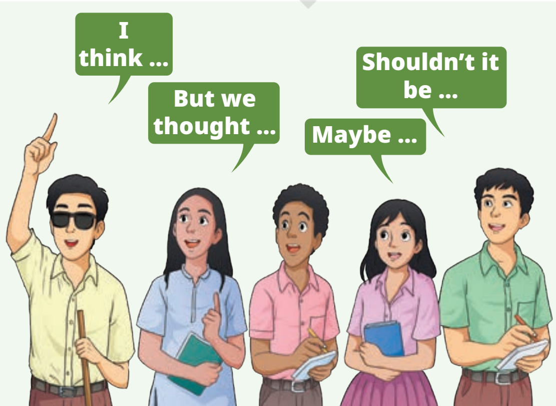



*Fig. 8.24*

7. What new substance is formed when a mixture of iron filings and sulfur powder is heated, and how is it different from the original mixture? Also, write the word equation for the reaction.
8. Is it possible for a substance to be classified as both an element and a compound? Explain why or why not.
9. How would our daily lives be changed if water were not a compound but a mixture of hydrogen and oxygen?
10. Analyse Fig. 8.24. Identify Gas A. Also, write the word equation of the chemical reaction.
11. Write the names of any two compounds made only from non-metals, and also mention two uses of each of them.
12. How can gold be classified as both a mineral and a metal?




**Reflect on the questions framed by your friends and try to answer ...**

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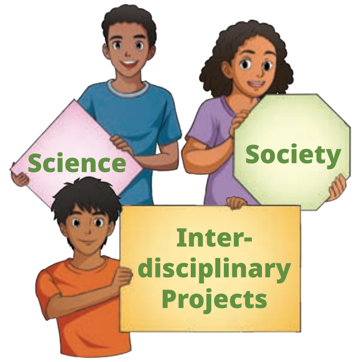
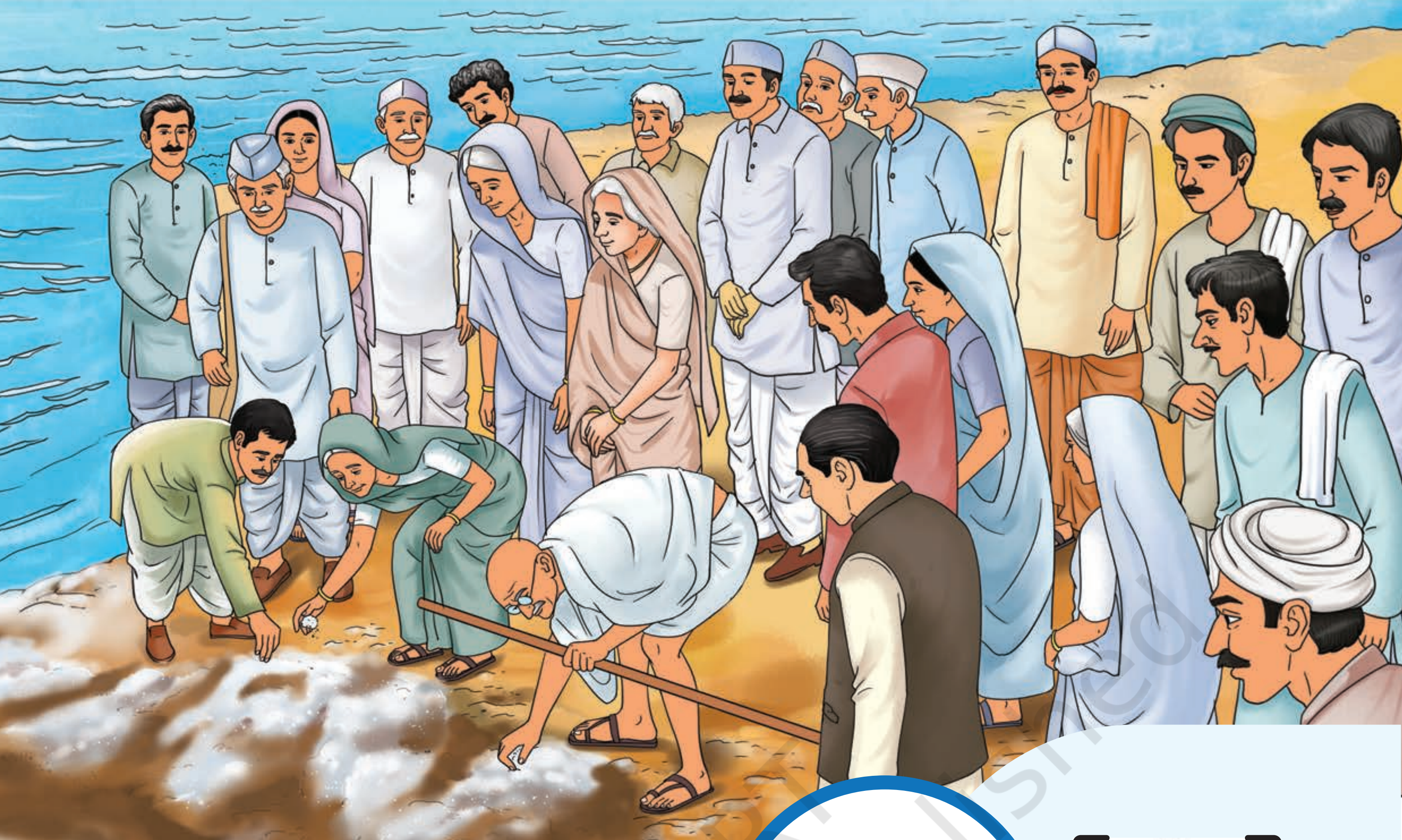
## Discover, design, and debate

- Design and create comic strips from real-life examples to differentiate between elements, compounds, and mixtures with diagrams and illustrate their properties and uses.
- Search for discoveries of some elements (such as phosphorus, sodium), compounds (such as penicillin) and mixtures (such as brass, bronze, stainless steel). Present your findings in the class.
- Let us search: Read labels on items like detergents or snacks, and try to list the mixtures and compounds they contain.
- Work in groups: Each group will pretend to be in the role of either an element, a compound, or a mixture. Debate which category among them is the most important.

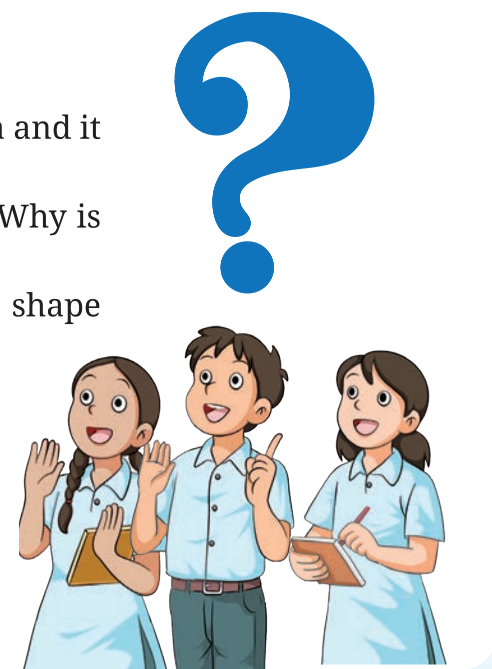




# The Amazing World of Solutes, Solvents, and Solutions

9

## Probe and ponder



- What do you think is happening in the picture above?
- What happens when you add too much sugar to your tea and it stops dissolving? How can you solve this problem?
- Why do sugar and salt dissolve in water but not in oil? Why is water considered a good solvent?
- Why are water bottles usually tall and cylindrical in shape instead of spherical?

Share your questions

______________________________

______________________________ ?

You must have taken an Oral Rehydration Solution (ORS) at some time in your life. ORS is used to treat dehydration by keeping your body hydrated. You have learnt to prepare ORS at home in *Curiosity*, Grade 6. You may have wondered why every sip of your homemade ORS tastes the same, no matter how much you drink. Why does it not taste salty in one sip and sweet in another?

This is because when you add sugar and salt to water, they form a mixture in which the components are evenly distributed throughout.

*Fig. 9.1: Mixture of sugar, salt, and water*

Can you **predict** whether this mixture is uniform or not (Fig. 9.1)? What happens when chalk powder is mixed with water—does it form a uniform mixture?

When salt and sugar are mixed with water, a **uniform mixture** is formed, whereas when chalk powder or sand, or sawdust is mixed with water, the components are not evenly distributed. Such mixtures are known as **non-uniform mixtures** (Fig. 9.2a and 9.2b).

*Fig. 9.2: Mixture of (a) Sand and water; (b) Sawdust and water*

Let us **explore** the science of mixing things together.

## 9.1 What Are Solute, Solvent, and Solution?

A uniform mixture, such as that of salt or sugar, and water, is called a solution. Whenever a solid is mixed with a liquid to form a solution, the solid component is called the **solute**, and the liquid component is called the **solvent**. The solute dissolves in the solvent to form a **solution** (Fig. 9.3).

Solute + Solvent ⟶ Solution

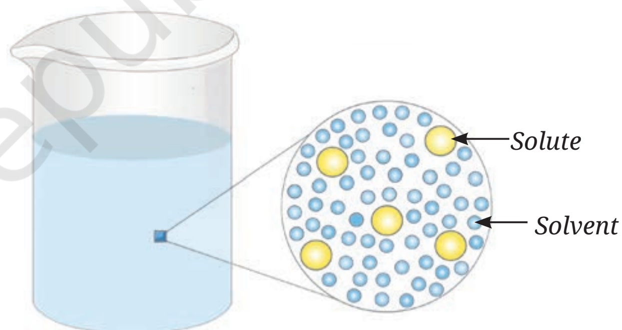
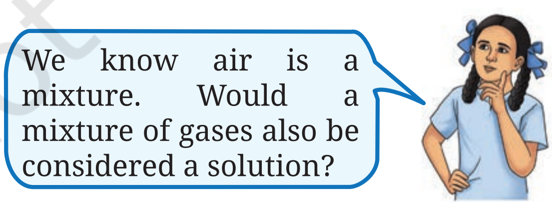



*Fig. 9.3: Magnified schematic picture of a solute evenly distributed in a solvent*

When a solution is formed by mixing two liquids, it is not always clear which substance is dissolving the other. In such cases, the substance present in smaller amount is called the solute, while the one in larger amount is called the solvent.




Just as water can act as a solvent in liquid solutions, gases can also form solution— with air being a common example.

Air is a gaseous solution. Since nitrogen is present in the largest amount in the air, it is considered as the solvent, while oxygen, argon, carbon dioxide, and other gases are considered as solutes.

## Ever heard of ...

The *Chashni* (sugar syrup) of the Indian sweet Gulab jamun is made of a large amount of sugar (solid) dissolved in a small amount of water (liquid). However, the water is still considered as the solvent and sugar as the solute (Fig. 9.4)!

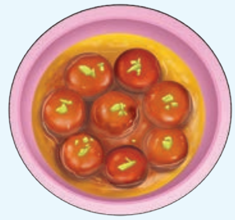


*Fig. 9.4: Gulab jamuns dipped in sugar syrup*

## 9.2 How Much Solute Can a Fixed Amount of Solvent Dissolve?

### Activity 9.1: Let us investigate


- Take a clean glass tumbler and fill it half with water.
- Add one spoon of salt into it and stir well till it dissolves completely (Fig. 9.5).
- Gradually add a spoonful of salt into the glass tumbler and stir. **Observe** how many spoons of salt you can add before it stops dissolving completely.
- **Record** your observations in Table 9.1.

**Table 9.1: Dissolution of salt in water**

| Amount of salt taken (teaspoon) | Observation (salt dissolves/salt does not dissolve) |
|---|---|
| One | |
| Two | |
| Three | |
| Four | |
| ... | |

### Some discussion points

- How many spoons of salt were you able to dissolve before some of it remained undissolved?
- What does this indicate about the capacity of water to dissolve salt?

You might have observed that, initially, the salt completely dissolves in the water, forming a solution. After adding a few more spoons of salt, a stage comes when the added salt does not dissolve completely and the undissolved salt settles at the bottom. This indicates that the water can no longer dissolve any more salt because it has reached its limit. The solution in which more solute can be dissolved at a given temperature, is called an **unsaturated solution** (Fig. 9.5). However, when the solute stops dissolving and begins to settle at the bottom, the solution is called a **saturated solution** at that particular temperature (Fig. 9.6).

*Fig. 9.5: Unsaturated solution*

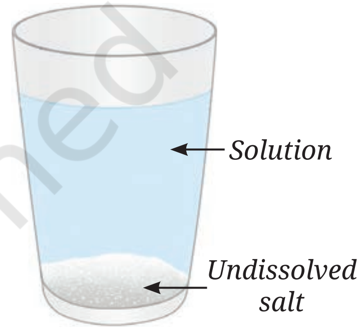



*Fig. 9.6: Saturated solution*

The amount of solute present in a fixed quantity of solution (or solvent) is termed as its **concentration**. Depending upon the amount of solute present in a fixed quantity of solution, it can be called a **dilute solution** (less amount of solute) or a **concentrated solution** (more amount of solute). Dilute and concentrated are relative terms.

So, one can say in Activity 9.1, the solution obtained by dissolving one spoon of salt is dilute as compared to that obtained by dissolving two or more spoons of salt.

Can you now **reflect** — which solution is more concentrated; 2 spoons of salt in 100 mL of water or 4 spoons of salt in 50 mL of water?

From Activity 9.1, we can say that the maximum amount of solute that dissolves in a fixed quantity of the solvent is called its **solubility**.

Does temperature affect the solubility of a solute?
Let us find out!

### 9.2.1 How does temperature affect the solubility of a solute?

#### Activity 9.2: Let us experiment (Demonstration activity)

- Take about 50 mL of water in a glass beaker and **measure** its temperature using a laboratory thermometer, say 20 °C.
- Add a spoonful of baking soda (sodium hydrogen carbonate) to the water and stir until it dissolves. Continue adding small amounts of baking soda while stirring, till some solid baking soda is left undissolved at the bottom of the beaker.

**Safety first**

Be careful while using the heating device.

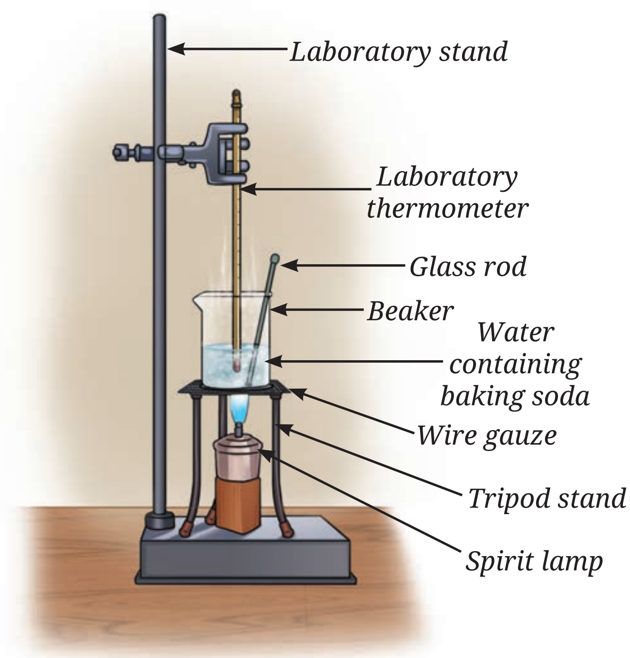



*Fig. 9.7: Dissolution of baking soda in water*

- Now, heat the contents to 50 °C while stirring (Fig. 9.7).
- What happens to the undissolved baking soda?
- You will observe that it has dissolved.
- Continue adding more baking soda while stirring at this temperature until some solid baking soda remains undissolved.
- Again, heat the contents further to 70 °C while continuing to stir. What do you observe?
- The undissolved baking soda dissolves.
- What do you **infer** from this experiment?

Water at 70 °C dissolves more baking soda than water at 50 °C. The amount of baking soda dissolved in water at 20 °C is even lesser.

It has been found that for most of the substances, the solubility increases with an increase in temperature. We can also say that a saturated solution at a particular temperature behaves as an unsaturated solution if the temperature is increased.

## Our scientific heritage

Water has primarily been used as a solvent for the preparation of medicinal formulations in Ayurveda, *Siddha*, and other traditional systems of medicine in India. Additionally, drug formulations have been prepared using hydro-alcoholic extracts of the herbs. The Indian systems of medicine have also referred to the use of oils, ghee, milk, and other substances as solvents for drug formulations, to help achieve the therapeutic benefits of the drug.

## Be a scientist

What inspired Asima Chatterjee to work on medicinal plants?

Asima Chatterjee is renowned for her work in developing anti-epileptic and anti-malarial drugs. She used solvents and solutions extensively to extract and isolate important compounds from medicinal plants. She earned a Doctorate of Science, becoming the second Indian woman to do so after Janaki Ammal. She became the first woman to receive the Shanti Swarup Bhatnagar Award in the field of chemical science and was also honoured with the Padma Bhushan.

Do gases also dissolve in water?

## 9.3 Solubility of Gases

Many gases, including oxygen, dissolve in water. Oxygen dissolves in water only to a small extent. Even though present in minute quantities, it is this dissolved oxygen that sustains all aquatic life, including plants, fishes, and other organisms.

Is the mixture of gases in water a uniform or non-uniform mixture?

It is a uniform mixture because the gases dissolve evenly in water to form a solution.

Does temperature affect the solubility of gases in liquids also? If so, how?

It has been observed that the solubility of gases generally decreases as temperature increases. More oxygen can dissolve in cold water, ensuring sufficient oxygen for aquatic life (Fig. 9.8). On the other hand, when water warms up, the solubility of oxygen decreases.

*Fig. 9.8: Aquatic species in water*

Now I understand that the mixtures we use can be of two types—uniform and non-uniform. Uniform mixtures are called solutions, and their components are not visible separately. In non-uniform mixtures, the components can be seen either with the naked eye or with a magnifying device.

I observed that in some non-uniform mixtures, such as sawdust in water, the sawdust floats, whereas in the mixture of sand and water, the sand sinks. I wonder why that happens?

## 9.4 Why Do Objects Float or Sink in Water?

*Fig. 9.9: Some objects float while others sink in water*

You must have observed that some objects float while others sink in water (Fig. 9.9). You may have noticed that, while washing rice, husk particles present in the rice float on the surface of water while rice sinks to the bottom of the container. Why does this happen? If you add oil to water, it floats on water. Generally, it is believed that objects that **float** in a liquid are lighter and others that **sink** are heavier than the liquid.

A wooden stick and an iron rod may be of the same size, yet the iron rod feels much heavier. When we say that iron is heavier than wood, we are referring to a special property known as density, which describes the heaviness of an object.

**Note**

However, the density of a substance is not the only factor that decides whether it will float or sink in a particular liquid.

Let us explore further.

## 9.5 What Is Density?

*Fig. 9.10 (a): Dense forest*

*Fig. 9.10 (b): Less dense forest*

Imagine a crowded bus where many people are packed together—this is an example of high density whereas, the same bus with only a few people is an example of low density. Similarly, a forest where trees grow close to each other is called a dense forest (Fig. 9.10a), but if the trees are far apart (Fig. 9.10b), it is considered less dense.

### How do scientists define density?

Let us find out.

We have learnt that matter is anything that possesses mass and occupies space (volume). **Density** is defined as the mass present in a unit volume of that substance.

The density of a substance may be expressed mathematically using the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The density of a substance is independent of its shape or size. However, it is dependent on temperature and pressure. Pressure primarily affects the density of gases, while its effect on solids and liquids is negligible.

The units in which density is expressed will depend upon the units of mass and volume taken. As you have learnt, the **SI units** of **mass** and **volume** are **kilogram** (**kg**) and **cubic metre** (**$m^3$**), respectively. Therefore, the **SI unit** of **density** is **kilogram per cubic metre**, abbreviated as **$kg/m^3$**. In case of liquids, other units of density are also used for convenience, such as gram per millilitre, abbreviated as g/mL and gram per cubic centimetre, abbreviated as $g/cm^3$.

## Conversion factor for density

$1\ kg/m^3 = 1000\ g/m^3 = 1000\ g/1000\ L = 1\ g/L = 1\ g/1000\ mL = 1\ g/1000\ cm^3$

The mass of 1 mL of water is close to 1 g at room temperature. For the measurement of the mass of water, we generally consider the volume in mL and its mass in g. Hence, 10 mL of water would be approximately 10 g. Similarly, 100 mL of water would be approximately 100 g.

Suppose the mass of an aluminium block is 27 g and its volume is 10 $cm^3$, its density is 2.7 $g/cm^3$.

From this, it can be said that aluminium is 2.7 times denser than water. We express this fact by saying that the relative density of aluminium with respect to water is 2.7. It is a number without any units.

$$\text{Relative density of any substance with respect to water} = \frac{\text{Density of that substance}}{\text{Density of water at that temperature}}$$

### Think like a scientist

Have you noticed that some packets of ghee or oil are labelled with a volume of 1 litre but a weight of only say 910 grams (Fig. 9.11)? What does this tell us about the density of the oil, and is it less or more than that of water?


*Fig. 9.11: Packed oil*

### 9.5.1 Determination of density

The density of an object can be determined by measuring its mass and volume.

## How to measure mass?

You learnt the term 'mass' in *Curiosity*, Grade 6. **Mass** is the quantity of matter present in any object. The instrument used to measure the mass of an object is known as a **balance**. You must have seen various types of balances being used by shopkeepers. Here, we are using a **digital weighing balance** to measure the mass. You learnt in chapter 'Exploring Forces' that on Earth, weight and mass are closely related.

You may measure the mass by doing the following activity.

## Activity 9.3: Let us measure

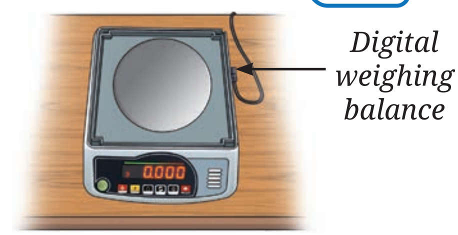



Fig. 9.12(a): Digital weighing balance

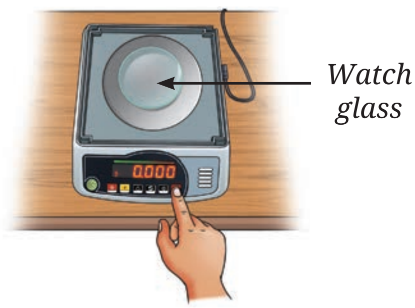



Fig. 9.12(b): Tare the balance after placing a watch glass

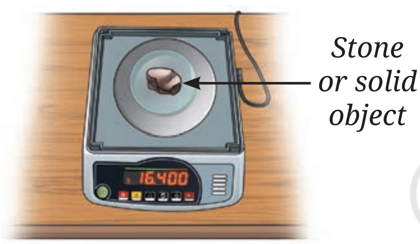



Fig. 9.12(c): Weighing a solid object on digital balance

- Switch ON the digital weighing balance.
- Observe the initial reading on the digital weighing balance display.
- It should show a zero reading. If not, then we must bring it to zero by pressing the tare or reset button (Fig. 9.12a).
- Place a dry and clean watch glass or butter paper on the pan.
- Note the reading on the digital weighing balance.
- Reset the digital weighing balance reading to zero by pressing the tare or reset button as shown in Fig. 9.12b.
- Now, carefully place the solid object, such as stone, on the watch glass (Fig. 9.12c).
- Note the reading displayed on the balance, which gives the mass of the stone, say 16.400 g.

(You may use any other type of balance available in your school.)

### Note

The mass of a liquid may be measured by replacing the watch glass with a beaker and pouring the desired amount of liquid into it.



### A step further

As mentioned in Chapter 5, the words 'mass' and 'weight' are often used interchangeably in everyday language. But they have different meanings in science, which can sometimes cause confusion. Mass is the quantity of matter present in an object or a substance. Its units are gram (g) and kilogram (kg). On the other hand, weight is the force by which the Earth attracts an object or a substance towards itself, and it is measured in newtons (N). Most balances (except two-pan balances like in Fig. 9.13) actually measure weight, but their scales are marked in mass units, so they show values in grams or kilograms (Fig. 9.12c).

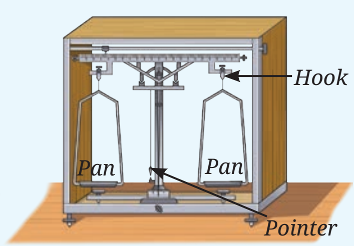



Fig. 9.13: Two-pan balance

## How to measure volume?

A tetra pack says it contains 200 mL buttermilk (*chach)* (Fig. 9.14). What does that mean?

You learnt in *Curiosity*, Grade 6 that **volume** is the space occupied by an object. You also know that the SI unit of volume is cubic metres, written as $m^3$. It is the volume of a cube whose each side is one metre in length. Volume of smaller objects is conveniently expressed in a decimetre cube ($dm^3$) or centimetre cube ($cm^3$). One centimetre cube is also written as one cc. Volume of liquids is expressed in litres (L) which is equivalent to 1 $dm^3$. A commonly used submultiple of a litre is millilitre (mL) which is equivalent to 1 $cm^3$.


*Fig. 9.14: A pack of buttermilk of 200 mL*

One of the common apparatuses used to measure the volume of liquids is a **measuring cylinder**. It is a narrow transparent cylindrical container with one side open and the other side closed as shown in Fig. 9.15. There are markings on the transparent body of the cylinder that indicate the volume of liquid in the measuring cylinder. We can use it to measure the desired amount of a liquid.

Measuring cylinders are available in different sizes to measure volume— 5 mL, 10 mL, 25 mL, 50 mL, 100 mL, 250 mL, etc (Fig. 9.15). How accurately can these measuring cylinders measure?

Let us find out!

*Fig. 9.15: Measuring cylinders of different capacities*



## Activity 9.4: Let us observe and calculate

In *Curiosity*, Grade 6, chapter 'Temperature and Its Measurement', you learnt how to use the thermometer and to find its smallest reading; you can do the same with a measuring cylinder.

Take a measuring cylinder and observe it carefully. Note down the following:

- What is the maximum volume it can measure?

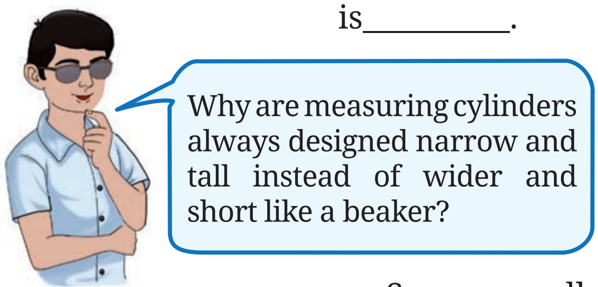
Now look at the measuring cylinder (Fig. 9.16) carefully. The cylinder is marked as 100 mL; therefore, it can measure volume up to 100 mL.

What is the smallest volume it can measure? Look at the measuring cylinder again.

- How much is the volume difference indicated between the two bigger marks (for example, between 10 mL and 20 mL)?

- How many smaller divisions are there between the two bigger marks?
- How much volume does one small division indicate?

The smallest volume that the measuring cylinder can read is__________.




For the measuring cylinder shown in Fig. 9.16, the volume difference indicated between 10 mL and 20 mL, or between 40 mL and 50 mL, is 10 mL.

The number of divisions between these marks is 10.

So, one small division can read 10 ÷ 10 = 1 mL.

That is, the smallest value that this measuring cylinder can read is 1 mL.

The smallest volume that a measuring cylinder can measure depends on the capacity of the measuring cylinder. Usually it is 0.1 mL in smaller measuring cylinders with a capacity of 10 mL or 25 mL, it is 1 mL in a 100 mL measuring cylinder, 2 mL in a 250 mL measuring cylinder, and 5 mL in a 500 mL measuring cylinder. Suppose we want to take 70 mL of water. If we use a 50 mL measuring cylinder, it would not be possible to measure 70 mL of water in one step. First, we have to measure 50 mL water and then 20 mL. Measuring volume in more than one step is not convenient. On the other hand, if a 250 mL or 500 mL measuring cylinder is used, the measurement can be done in one step but the accuracy would be reduced as the smallest volume that these measuring cylinders can measure is greater than that of a 100 mL measuring cylinder. Hence, a 100 mL measuring cylinder is the best choice for this measurement.

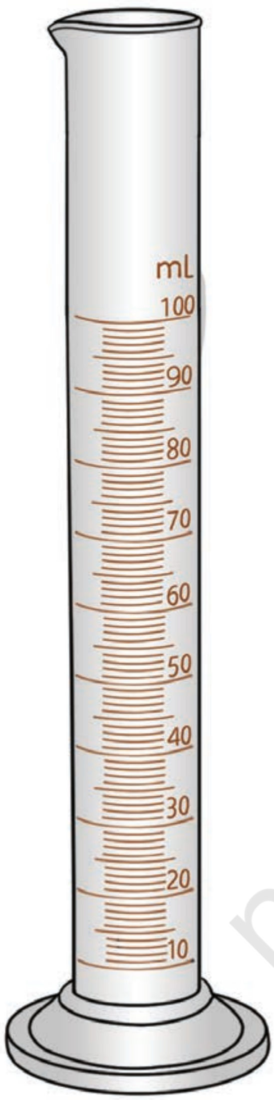



*Fig. 9.16: Measuring cylinder of 100 mL*

## Activity 9.5: Let us measure 50 mL of water

- Place a clean, dry measuring cylinder on a flat surface.
- Pour water slowly into the measuring cylinder up to the required mark, as shown in Fig. 9.17.
- If required, adjust the level of water in the measuring cylinder by adding or removing a small amount of water using a dropper.
- On careful observation, you will notice that the water inside the measuring cylinder forms a curved surface. This curved surface is called the **meniscus** (Fig. 9.18).
- Read the mark on the measuring cylinder that coincides with the bottom of the meniscus for water or other colourless liquids.

- Make sure that the eyes are at level with the bottom of the meniscus while noting the readings as shown in Fig. 9.18.

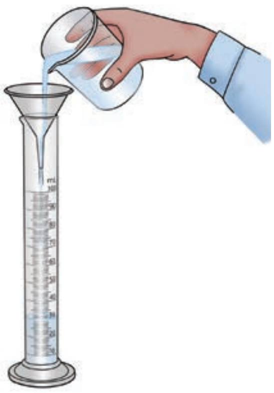


*Fig. 9.17: Pouring water into the measuring cylinder*

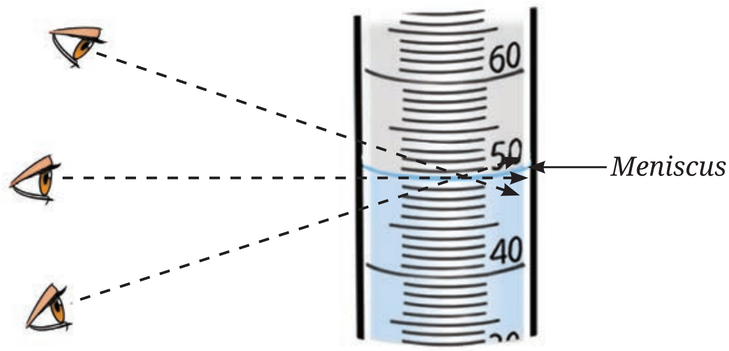
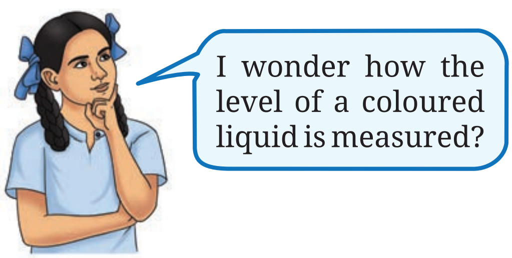



*Fig. 9.18: Measuring the reading*




- Once it reaches the required level—that is, 50 mL—transfer this water to the required container.

In case of coloured liquids the mark on the measuring cylinder should coincide with the top of the meniscus!

### Determining volume of solid objects with regular shapes

## Activity 9.6: Let us calculate

- **Collect** various objects with a cuboid shapes, such as a notebook, a shoe box, or a dice.
- Measure the length ($l$), width ($w$), and height ($h$) of the objects using a scale. Suppose the length of the notebook is 25 cm, the width is 18 cm, and the height is 2 cm.
- **Calculate** the volume by using the following formula.

$$\text{Volume} = l \times w \times h$$

$$\text{Volume} = 25\text{ cm} \times 18\text{ cm} \times 2\text{ cm} = 900\text{ cm}^3$$

- Record in your notebook.

### Determining volume of objects with irregular shapes

Imagine you have an object, like a stone, that does not have a regular shape. To calculate its density, the main challenge is to find its volume. Let us learn how the volume of a solid with an irregular shape can be determined.

## Activity 9.7: Let us measure

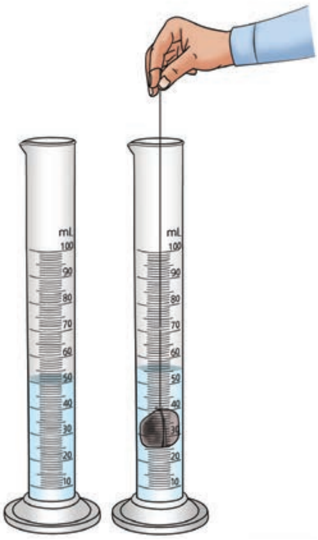


*Fig. 9.19: Level of water in the measuring cylinder (a) Without object; (b) With object*

- Collect various objects from your surroundings, such as a stone, metal keys, and so on.
- Fill a measuring cylinder with water up to any desired volume, say 50 mL (Fig. 9.19a) and record the initial volume taken in Table 9.2.
- Tie the object, say a stone, with a thread and slowly lower it into the measuring cylinder.
- What do you notice?
- Record the final volume after the level rises, say 55 mL, as shown in Fig. 9.19b.
- Subtract the initial volume from the final volume after the object is put into the measuring cylinder. This is the volume of the object.
- Record your observations in Table 9.2.

**Table 9.2: Volume of irregular solids**

| S.No. | Object | Initial volume of water in the measuring cylinder (mL) (A) | Final volume of water in the measuring cylinder (mL) (B) | Volume of water displaced in the measuring cylinder (mL) (B–A) | Volume of the object ($cm^3$) |
|---|---|---|---|---|---|
| 1. | Stone | 50 mL | 55 mL | 5 mL | 5 $cm^3$ |
| 2. | Metal key | | | | |
| 3. | Any other | | | | |

**Note**

The values of volume are obtained in units of mL, which can be written in the equivalent unit $cm^3$ for solids.



We have already learnt to measure the mass and volume of liquids and solids of different types. These quantities can be used to calculate the density of the object or the substance.

### Let us calculate the density

Density can be calculated using the following formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{16.400\text{ g}}{5\text{ cm}^3} = 3.28\text{ g/cm}^3$$

## Let us dig deeper!

Did you know that our planet, Earth, is composed of several layers, such as crust, upper mantle, lower mantle, outer core, and inner core, each with its particular range of density? The outermost layer, called the crust, is the lightest and the density of the different layers increases as we move towards the centre (Fig. 9.20). As one moves deeper into the Earth, both the pressure and the temperature rise significantly, making the materials heavier and more compact.

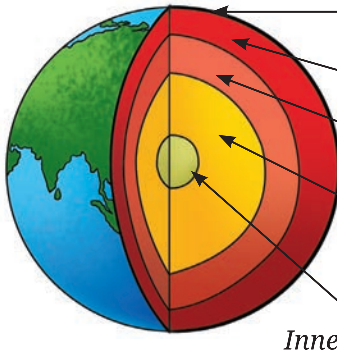



*Fig. 9.20: Layers of Earth*

### Ever heard of ...

*Fig. 9.21: Bamboo raft floats on water*

In ancient times, before large ships were invented, people used bamboo and wooden logs to travel across rivers and seas (Fig. 9.21). Bamboo was used because it is light, hollow, and floats easily on water. People tied bamboo poles together to make rafts and small boats for fishing, trading, and crossing water bodies. Wooden logs, especially from strong trees were either hollowed out to make boats or used as rafts. These simple boats, made from locally available materials, were important for moving around and connecting different places. Even today, similar traditional boats made of bamboo or wood are used in some regions—not just for transport, but also as tourist attractions.



## 9.5.2 Effect of temperature on density

Generally, the density of a substance decreases with heating and increases with cooling. This can be explained on the basis of what you have learnt in chapter 'Particulate Nature of Matter'. As temperature increases, the particles of a substance whether, solid, liquid, or gas, tend to move away and spread. This results in an increase in volume but there is no change in mass. Since the Density = Mass/Volume, upon heating, the volume increases and the density decreases. This explains why hot air moves up as it is less dense than the cool air around it. The hot air balloon works on the same principle (Fig. 9.22).

*Fig. 9.22: Rising of hot air balloons*

### 9.5.3 Effect of pressure on density

Pressure affects density differently depending on the state of matter. For gases, increasing pressure causes the particles to move closer together. As a result, the volume of the gas decreases and its density increases. In the case of liquids, pressure has a small effect because they are nearly incompressible. We have learnt in chapter 'Particulate Nature of Matter' that the particles in solids are very close to each other. So, how is the density of solids affected when pressure is applied? Solids are even less affected by pressure than liquids, and changes in their density are usually negligible.

#### Ever heard of ...

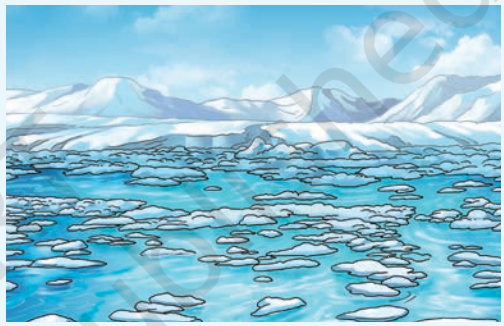


Fig. 9.23: Ice floats on water

Why does ice float on water? Ice floats on water because it is lighter than liquid water (Fig. 9.23). Water has a special property that its density is highest at 4 °C. It means water is heaviest at 4 °C. As the temperature drops, and water turns into ice at 0 °C, it undergoes a change in structure—the particles arrange themselves in a way that takes up more space. This process is called expansion. Because the same amount of water now occupies a larger volume, its density decreases. As a result, ice becomes lighter than liquid water and floats on its surface.

This is important for animals living in lakes and oceans because ice floats, it forms a layer on top, keeping the water underneath warm enough for fish and other creatures to survive, even in extremely cold weather.

#### Think like a scientist

- Take a glass tumbler and fill it with tap water. Carefully place a raw whole egg into the water and observe what happens. You will notice that the egg sinks to the bottom (Fig. 9.24).
- What change can you make to this setup to make the egg float in water instead of sinking?
- In this chapter, you have learnt the concept of density and how it explains partially why some objects float while others sink.

Fig. 9.24: Raw whole egg sinks in water

## Snapshots

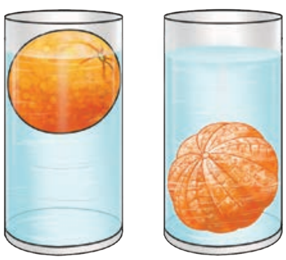
- A solution is said to be formed when two or more substances mix to form a uniform mixture.
- In the solution formed by dissolving a solid in a liquid, the solid component is known as a solute and the liquid component is known as a solvent.
- In a solution formed by mixing two liquids, the component present in less quantity is known as solute and the other component is called solvent.
- In air, nitrogen is considered as a solvent, while oxygen, argon, carbon dioxide, and other gases are considered as solutes.
- A solution in which the maximum amount of solute has been dissolved, and no more of it can be dissolved at that temperature is called a saturated solution.
- A solution in which more solute can be dissolved at a given temperature is called an unsaturated solution.
- Solubility is the maximum amount of solute that can be dissolved in a fixed quantity (100 mL) of a solution or a solvent at a particular temperature.
- Generally, in liquids, the solubility of solids increases and that of gases decreases with an increase in temperature.
- The amount of matter present in an object is known as its mass.
- The space occupied by an object or a substance is known as its volume.
- Devices used to measure mass and volume are a weighing balance and a measuring cylinder, respectively.
- The mass per unit volume of a substance is known as its density (Density = Mass/Volume).
- Generally, density decreases with an increase in temperature and pressure affects density differently depending on the state of matter.



## Keep the curiosity alive

1. State whether the statements given below are True [T] or False [F]. Correct the false statement(s).
   (i) Oxygen gas is more soluble in hot water rather than in cold water.
   (ii) A mixture of sand and water is a solution.
   (iii) The amount of space occupied by any object is called its mass.
   (iv) An unsaturated solution has more solute dissolved than a saturated solution.
   (v) The mixture of different gases in the atmosphere is also a solution.

2. Fill in the blanks.
   (i) The volume of a solid can be measured by the method of displacement, where the solid is __________ in water and the ____________ in water level is measured.
   (ii) The maximum amount of _______________ dissolved in _______________ at a particular temperature is called solubility at that temperature.
   (iii) Generally, the density ____________ with increase in temperature.
   (iv) The solution in which glucose has completely dissolved in water, and no more glucose can dissolve at a given temperature, is called a __________ solution of glucose.
3. You pour oil into a glass containing some water. The oil floats on top. What does this tell you?
   (i) Oil is denser than water
   (ii) Water is denser than oil
   (iii) Oil and water have the same density
   (iv) Oil dissolves in water
4. A stone sculpture weighs 225 g and has a volume of 90 $cm^3$. Calculate its density and predict whether it will float or sink in water.
5. Which one of the following is the most appropriate statement, and why are the other statements not appropriate?
   (i) A saturated solution can still dissolve more solute at a given temperature.
   (ii) An unsaturated solution has dissolved the maximum amount of solute possible at a given temperature.
   (iii) No more solute can be dissolved into the saturated solution at that temperature.
   (iv) A saturated solution forms only at high temperatures.
6. You have a bottle with a volume of 2 litres. You pour 500 mL of water into it. How much more water can the bottle hold?
7. An object has a mass of 400 g and a volume of 40 $cm^3$. What is its density?
8. Analyse Fig. 9.25a and 9.25b. Why does the unpeeled orange float, while the peeled one sinks? Explain.
9. Object A has a mass of 200 g and a volume of 40 $cm^3$. Object B has a mass of 240 g and a volume of 60 $cm^3$. Which object is denser?



*(a)* *(b)*

*Fig. 9.25*




**Prepare some questions based on your learnings so far ...**

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10. Reema has a piece of modeling clay that weighs 120 g. She first moulds it into a compact cube that has a volume of 60 cm³. Later, she flattens it into a thin sheet. Predict what will happen to its density.
11. A block of iron has a mass of 600 g and a density of 7.9 g/cm³. What is its volume?
12. You are provided with an experimental setup as shown in Fig. 9.26a and 9.26b. On keeping the test tube (Fig 9.26b) in a beaker containing hot water (~70 °C), the water level in the glass tube rises. How does it affect the density?

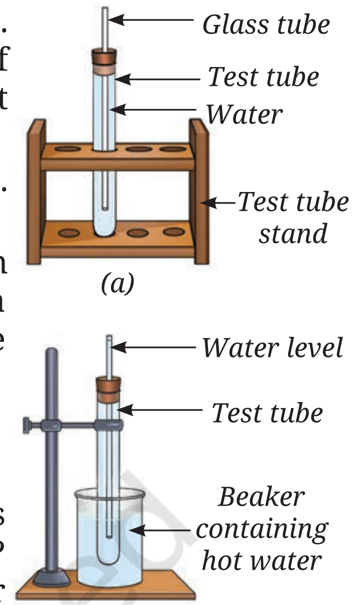
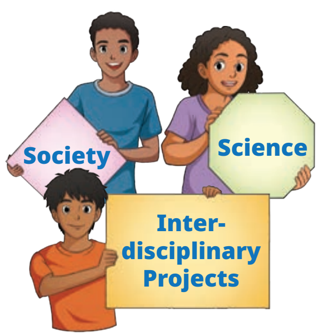


Fig. 9.26

## Discover, design, and debate




- Research project on Dead Sea: Why is there no aquatic life in the Dead Sea? Try to find out if there are any other similar water bodies.
- Investigate how well common salt dissolves in different solvents, such as water, vinegar, and oil. Compare the solubility of salt in each solvent and record your observations.
- Debate in class—Is water truly the most versatile solvent?

## Our scientific heritage

Ningel village in Manipur's Thoubal district is a place where salt is still produced using traditional methods. The village has a few salt wells, one of which is lined with a 100-year-old tree trunk placed into the ground to draw up salty water. A few families mostly women, continue this sacred practice by collecting the salt solution and boiling it in large metal pans over firewood kilns. Once the water evaporates and salt crystals form, they are shaped into round 'salt cakes' using banana leaves and handmade tools. These cakes are then wrapped in a traditional cloth (*phanek*) to protect them. The salt cakes are believed to have some medicinal value too.

Salt in Ningel is more than just food— it is history, culture, belief, and a beautiful example of India's living heritage.

**Reflect on the questions framed by your friends and try to answer ...**

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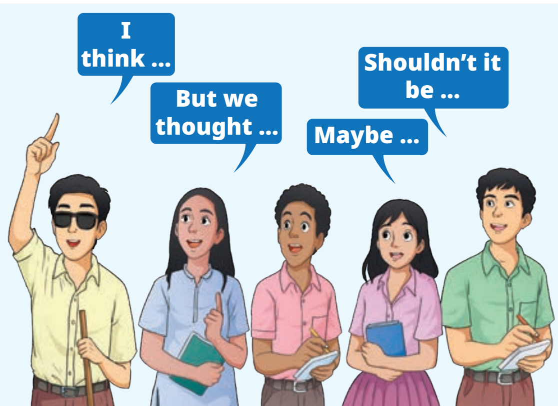


# Light: Mirrors and Lenses

# 10



0877CH10

## Probe and ponder

- Can we make mirrors which can give enlarged or diminished images?
- On side-view mirrors of vehicles, there is a warning that says "Objects in mirror are closer than they appear". Why is this warning written there?
- Why is there a curved line on some reading glasses?
- Share your questions

______________________________

______________________________ ?

During the summer holidays, Meena went to a science centre with her family. The centre had many fascinating displays on nature, space, and technology. While her parents explored a section on saving water and electricity, Meena and her brother wandered off to look around. In one corner, Meena noticed a row of unusual, curved mirrors. Curious, she stepped closer and looked into one. Her face appeared unusually large, while her brother, standing a little farther away, looked upside down! At another mirror, she saw a tiny version of herself. Meena was puzzled.

She remembered doing activities with a mirror earlier where the image formed by the mirror was of the same size as the object and was erect (in the chapter 'Light: Shadows and Reflections' in *Curiosity*, Grade 7). Seeing her confusion, a guide from the science centre walked up to her and smiled. "These are not plane mirrors," the guide explained. "These are spherical mirrors. When the mirror is curved inward or outward, your image looks different in them!" Meena's curiosity grew and she decided to talk to her teacher about these spherical mirrors.

## 10.1 What Are Spherical Mirrors?

### Activity 10.1: Let us explore

- Take a shiny metallic spoon and hold its curved surface close to your face. Can you see your image in it?
- **Notice** the image of your face. Is it different from the image you see in a plane mirror?
- While **observing** the image, slowly move the spoon away from your face. Do you observe any change in the image?
- Now flip the spoon and repeat the same steps.

(a) (b)

*Fig. 10.1: Image formed in a shiny metallic spoon from its (a) Inner curved surface; (b) Outer curved surface*

Did you notice that the shiny metallic spoon acted like a mirror and you could see your image in it? When you looked at the inner side of the spoon which is curved inwards, you must have observed that the image was inverted (Fig. 10.1a). When you looked at the outer side of the spoon which bulges outwards, the image of your face was erect but smaller in size (Fig. 10.1b).

Curved mirrors, like the spoon, can also be specially made. Spherical mirrors are a common type of curved mirrors which are shaped like a part of a hollow glass sphere. Mirrors, whose reflecting surfaces are spherical are called **spherical mirrors**.

The reflecting surface of the spherical mirror may be curved inwards or outwards. A spherical mirror, which has a reflecting surface that curves inwards, is called a **concave mirror** (Fig. 10.2a). Its schematic representation is shown in Fig. 10.2b. The outline of the surface of the mirror is circular.

*(a) (b)*

*Fig. 10.2: (a) Concave mirror; (b) Its representation*

*(a) (b)*

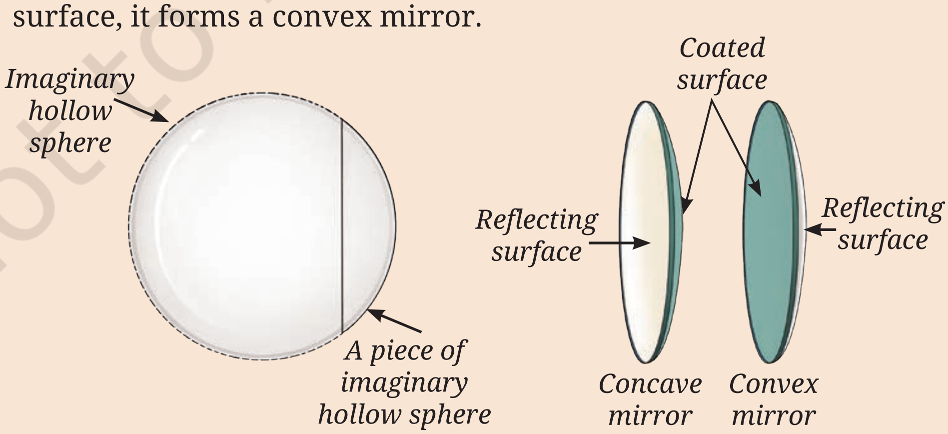
*Fig. 10.3: (a) Convex mirror; (b) Its representation*

A spherical mirror which has a reflecting surface that curves outwards is called a **convex mirror** (Fig. 10.3a). Its schematic representation is shown in Fig. 10.3b.

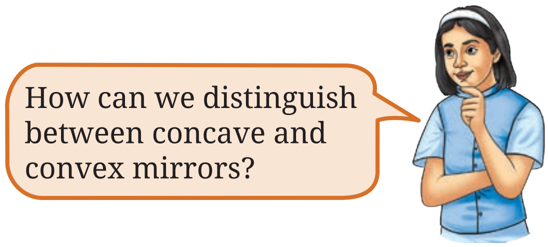
In the representation of both the mirrors, the non-reflecting surface of the mirror is shown as shaded.

## A step further

The shape of a spherical mirror is such that it can be thought of as a part of an imaginary hollow sphere. However, remember that spherical mirrors are not made by slicing a hollow glass sphere. Instead, they are created by grinding and polishing a flat glass piece into a curved surface. If a reflective coating (like a thin layer of aluminium) is applied on the outer curved surface, it forms a concave mirror. If the coating is applied on the inner curved surface, it forms a convex mirror.




## Activity 10.2: Let us distinguish




- Place concave and convex mirrors on a table with their reflecting surfaces facing upwards.
- Now view them from the side, keeping your eye at their level, to **identify** whether the reflecting surface is curved inwards or outwards (Fig. 10.4).

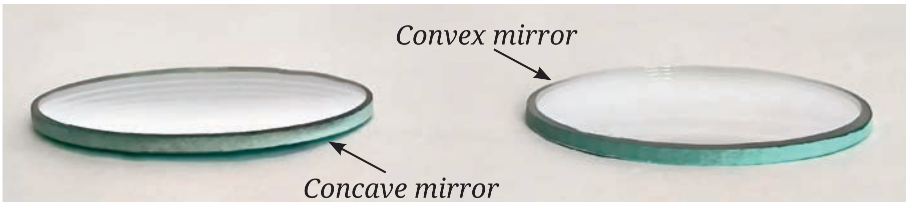



*Fig. 10.4: Identifying concave and convex mirrors from their side view*

## 10.2 What Are the Characteristics of Images Formed by Spherical Mirrors?

## Activity 10.3: Let us explore

- Take a concave mirror, a convex mirror, two small wooden blocks or something similar to place the mirrors in an upright position, and a small toy or some other object.
- Place the two mirrors side by side in an upright position on a table. Keep the object in front of them at a small distance (3–4 cm away) as shown in Fig. 10.5a. What kind of images do you see in each mirror? Are the images of the same size as the object? Are they erect? Do you see lateral inversion in the images? Write down your observations in your notebook.

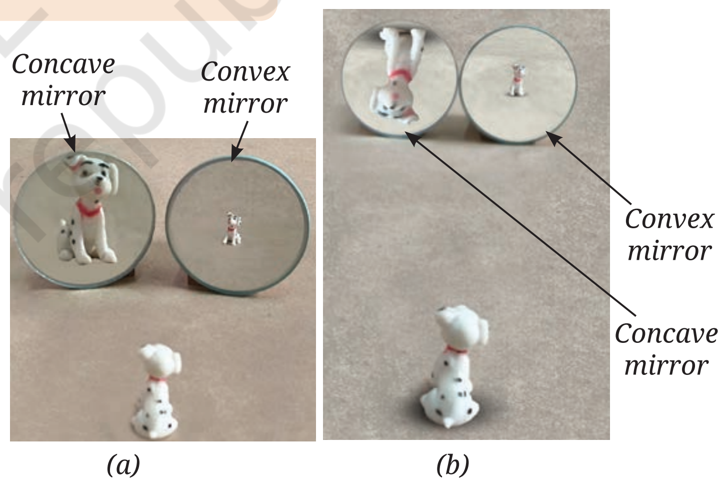


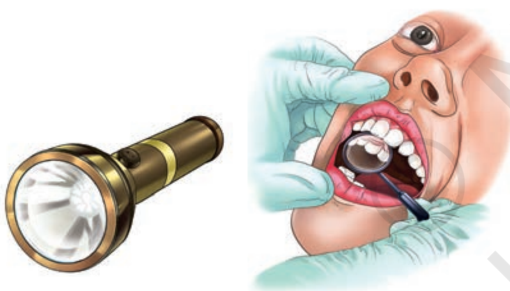

*Fig. 10.5: An object placed in front of concave and convex mirrors at (a) Small distance; (b) Large distance*

- Now slowly move the object away from the mirrors. What changes do you see in the images in both the mirrors? Do the images become smaller or larger? Do they continue to be erect? Again, note down your observations.
- Repeat the steps with each mirror individually.
- **Analyse** your observations and **draw conclusions**.

In the concave mirror, when the object is placed close to the mirror, the image is erect but larger than the object in size, that is, **enlarged**. However, when the object is moved farther away, the image becomes inverted. Initially, the image is enlarged in size and then keeps getting smaller. In case of a convex mirror, the image is always erect and smaller than the object, that is **diminished**. However, the size of the image decreases slightly as the object is moved away from the convex mirror.

This activity shows that spherical mirrors (concave and convex) behave differently from plane mirrors. A plane mirror always forms an erect image of the same size as the object. However, in the concave and convex mirrors, the size of the image changes as the distance of the object from the mirror changes. In addition, in the case of a concave mirror, the image also gets inverted when the object is taken away from the mirror. Lateral inversion of the image is seen in all three types of mirrors.





(a) (b)

*Fig. 10.6: Use of concave mirror (a) As a reflector of a torch; (b) By a dentist*

The reflectors of torches, headlights of cars and scooters are concave in shape (Fig. 10.6a). Have you ever noticed a dental mirror used by a dentist for inspecting teeth? It is a concave mirror which provides an enlarged view of teeth when held close to the teeth inside the mouth (Fig. 10.6b).

## A step further

Do you remember learning about the use of telescope in the chapter 'Beyond Earth' in *Curiosity*, Grade 6? Most modern telescopes are reflecting telescope that use curved mirrors, with the main mirror being a large concave mirror.

Look at the side-view mirrors on vehicles. These mirrors are convex. They always form an erect image of the traffic behind and smaller than the actual vehicles. Also, since the convex mirror is

(a) (b) (c)

*Fig. 10.7: Use of convex mirror as a (a) Side-view mirror; (b) Road safety mirror; (c) Surveillance mirror*

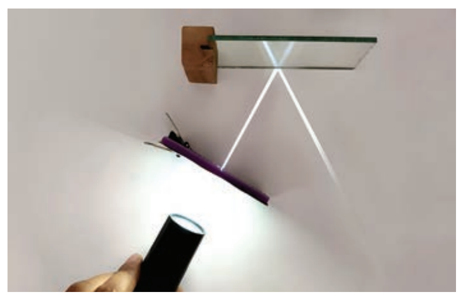
curved outside, it provides a much wider area of the road behind. Further, such convex mirrors are installed at road intersections or sharp bends to provide drivers from both sides the visibility of the other side and prevent collisions. Convex mirrors are also installed in big stores to monitor a large area to deter thefts.


## 10.3 What Are the Laws of Reflection?

Let us now repeat an activity which we did earlier in grade 7, but this time we will extend it further. Do you remember doing the activity for observing the reflection of a beam of light from a plane mirror?

### Activity 10.4: Let us experiment

- Collect a plane mirror with stand, a torch, a comb, a paper clip to hold the comb upright, a sheet of white paper, and a strip of black paper.
- As you did earlier, make a thin slit by covering all openings of the comb using black paper, except for one in the middle.
- Spread a sheet of white paper on a table. Place the plane mirror upright on it.
- Using the thin slit and torch, obtain a thin beam of light along the paper and adjust it to fall upon the mirror as shown in Fig. 10.8a.
- Now, move the slit and torch slightly so that the beam of light falls at a different angle on the mirror (Fig. 10.8b). Does the reflected beam of light also shift?



(a)

(b)

*Fig. 10.8: A beam of light falling on a mirror (a) At one angle; (b) At another angle*

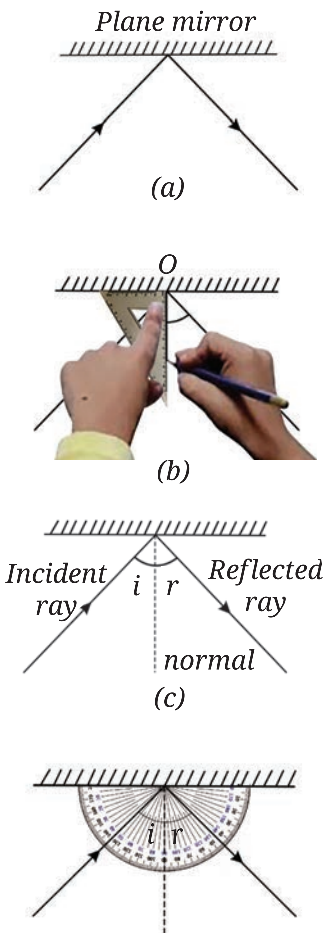


Fig. 10.9: (a) Drawing incident and reflected rays; (b) Drawing the normal; (c) Angle of incidence and angle of reflection; (d) Measuring angles

- Make the beam of light fall on the mirror at different angles and observe how the direction of the reflected beam changes.

To understand this better, let us **draw** this on a paper, step by step. But before doing that, let us learn how to represent light. We often represent light by straight lines with arrows, or **rays**. Rays indicate the path along which light travels. Do you remember learning earlier that the light travels along a straight line?

- Draw a line showing the position of the plane mirror. Also, draw lines with arrows (rays) indicating the beam of light falling on the mirror and the reflected beam of light as shown in Fig. 10.9a.

The ray of light that falls on the mirror is called the **incident ray**. The ray of light that comes back from the mirror is called the **reflected ray**.

- Now remove the mirror. From the point where the incident ray strikes the mirror, draw a line making an angle of 90° to the line representing the mirror. This line is known as the **normal** to the reflecting surface at the point of incidence, O (Fig. 10.9b).

The angle between the normal and the incident ray is called the **angle of incidence** (*i*) (Fig. 10.9c). The angle between the normal and the reflected ray is known as the **angle of reflection** (*r*) (Fig. 10.9c).

- On your drawing, **measure** the angle of incidence and the angle of reflection and note it in Table 10.1.
- Repeat the activity several times by changing the angle of incidence.
- Finally, let the incident beam fall on the mirror along the normal and observe the direction of the reflected beam. What would be the angle of incidence and angle of reflection in this case? Both the angles would be zero in this case.

**Table 10.1: Measuring angles of incidence and reflection**

| S.No. | Angle of incidence (*i*) | Angle of reflection (*r*) |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

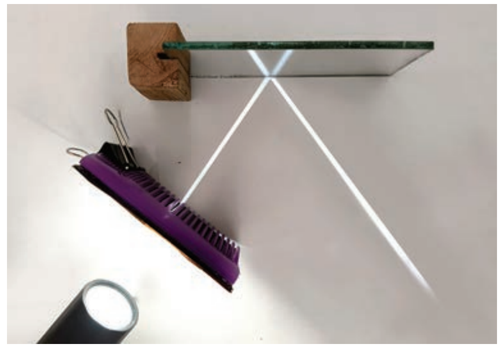
Do you notice that both angles in Table 10.1 are nearly equal? If done carefully, the experiment shows that **the angle of incidence (*i*) is equal to the angle of reflection (*r*)**. This is a law of reflection.

## Activity 10.5: Let us experiment

- Use the same setup as in Activity 10.4, but place a stiff sheet of chart paper flat on a table such that part of it extends beyond the edge of the table.
- Shine a beam of light on the mirror placed on the sheet and observe the reflected beam on the extended portion (Fig. 10.10a).
- Now, bend the extended part of the sheet along the edge of the table. Do you still see the reflected beam on the extended portion?
- Flatten the paper again and observe.

The reflected beam disappears when the sheet is bent but reappears when it is flattened again. This shows that the reflected beam lies in the same plane as that of the incident beam. Bending the sheet creates a new plane, breaking this alignment.

**The incident ray, the normal to the mirror at the point of incidence, and the reflected ray, all lie in the same plane.** This is another law of reflection.



*(a)*

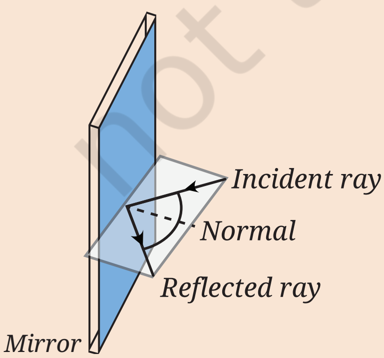
*(b)*

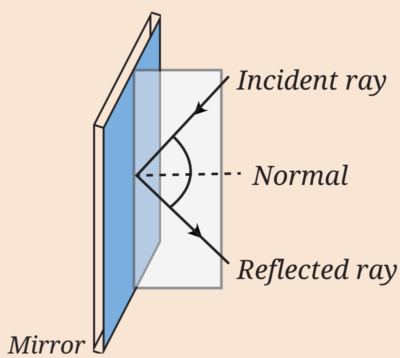
*Fig. 10.10: (a) Reflected beam visible along the extended portion of paper; (b) Reflected beam not visible along the bent portion of paper*

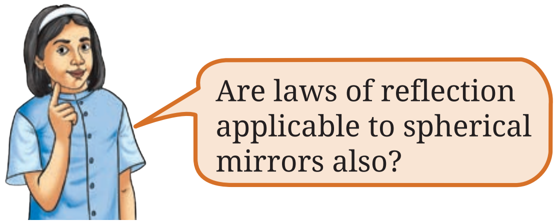


### A step further

In the two cases, even though the directions of incident rays are different, they fall at the same point on the mirror, and thus, the directions of normal are the same. However, the direction of the reflected ray is such that the incident ray, the normal at the point of incidence, and the reflected ray all lie in the same plane in both cases.




The laws of reflection are valid for all kinds of mirrors—plane and spherical. But if multiple parallel rays fall on the spherical mirrors, we observe something interesting.

## Activity 10.6: Let us explore

- Collect a plane mirror, a concave mirror, a convex mirror, stand for mirrors, a torch, a comb, and a paper clip to hold the comb upright.
- Use the same setup as Activity 10.4 again, but instead of a single slit, leave many openings of the comb uncovered to obtain multiple parallel beams of light (Fig. 10.11a).
- Let the multiple parallel beams of light fall upon the plane mirror, concave mirror, and convex mirror, one by one. Observe the reflected beams. Is your observation similar to what is shown in Fig. 10.11 (b), (c), and (d)?

When multiple parallel beams of light fall upon a plane mirror, the multiple reflected beams are also parallel (Fig. 10.11b). However, when multiple beams of light fall upon a concave mirror, the multiple reflected beams get closer, that is, they **converge** (Fig. 10.11c). Whereas, in the case of a convex mirror, the multiple reflected beams spread, that is, they **diverge** (Fig. 10.11d).

In the case of spherical mirrors, even though each ray of light follows the laws of reflection, the curved surface of spherical mirrors causes the parallel beam of rays to either converge (concave) or diverge (convex) on reflection depending on the shape of the mirror.

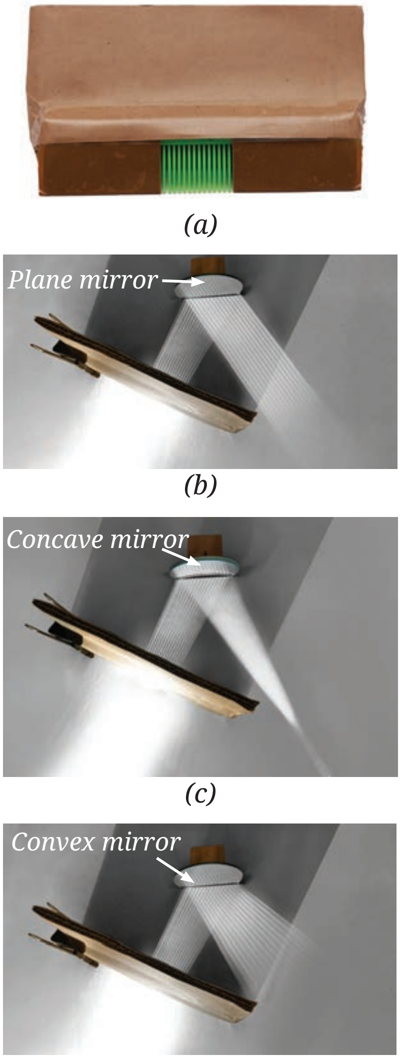
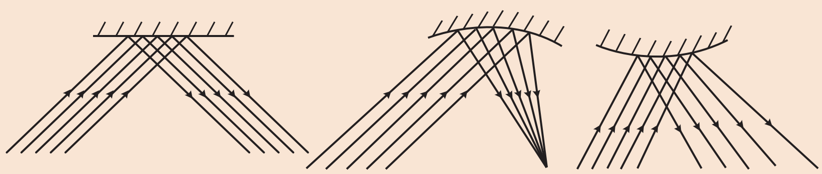



*Fig. 10.11: (a) Multiple slits; Multiple parallel beams of light fall upon — (b) Plane mirror; (c) Concave mirror; (d) Convex mirror*

### A step further

If we draw what we observed in Activity 10.6, we get the figures like those shown below.



*Plane mirror* *Concave mirror* *Convex mirror*

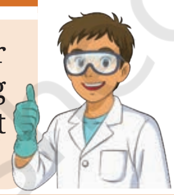
So, the concave mirror converges a light beam while the convex mirror diverges it. This is indeed interesting!

Since the concave mirror converges the light beam, wouldn't light get concentrated in a small area?

## Activity 10.7: Let us explore

### Safety first

Always perform this activity under the supervision of a teacher or an adult. Do not look towards the Sun or into the mirror reflecting the Sun. Focus the reflected light only on a piece of paper, not towards anyone's face or eyes.



- Take a concave mirror and a sheet of thin paper or newspaper.
- Hold the concave mirror with its reflecting surface facing the Sun. Direct the light of the Sun reflected by the mirror on the sheet of paper.
- Adjust the distance of the paper until you get a sharp bright spot on it as shown in Fig. 10.12.
- Hold the mirror and the sheet of paper steady for a few minutes. Does the paper start to burn producing smoke?

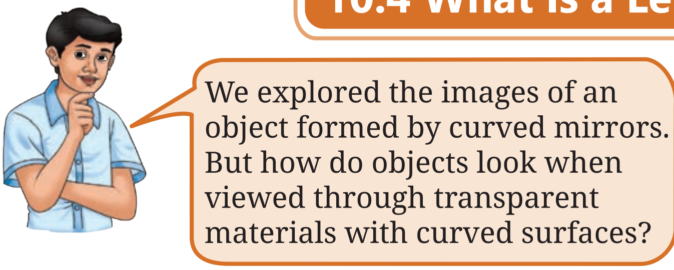

*Fig. 10.12: Converging sunlight on paper using a concave mirror*

The bright spot is formed on the paper because light from the Sun, after reflection from the mirror, gets concentrated on this point. This produces sufficient heat at this point which can ignite the paper.

### A step further

Devices which concentrate sunlight into a small area, using mirrors and lenses, are called solar concentrators. The concentrated sunlight is used to heat a liquid to produce steam which can be used to generate electricity or for providing heat for various purposes, such as large scale cooking or for solar furnaces. Solar furnaces are even used for melting steel! Do you remember learning in an earlier chapter, about electric furnaces for melting steel?

## 10.4 What Is a Lens?




Imagine looking through a flat transparent glass window pane—all objects look the same size and shape. But would those objects continue to look the same if the surface of the transparent material is curved?

### Activity 10.8: Let us explore

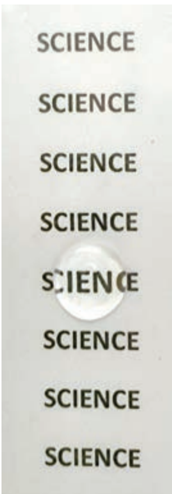



*Fig. 10.13: View of text beneath the water drop*

- Collect a flat strip of glass or clear plastic, such as a flat scale, few drops of oil, dropper, water, and a paper or book with some text printed on it.
- Spread a few drops of oil on the surface of glass or plastic strip and rub it to leave a very thin coating. You can also use wax instead of oil.
- Using a dropper or your finger, place a small drop of water on the oiled/waxed spot. (The oil/wax helps the water form a nice round drop.)
- **Examine** the water drop. What is the shape of its surface? Is it flat or curved inward or curved outward?
- Place the paper underneath the glass/plastic strip such that the text is directly under the water drop (see Fig. 10.13).
- Now, look down through the water drop at the text below. Do you find some change in the size of the letters just below the water drop? Do they look enlarged or smaller?

The surface of the water drop is curved outside. The letters under the water drop look different— they might appear larger than the letters nearby! The curved surface of the water drop made the size of the text look different. This curved drop of water is acting like a simple lens. Have you seen a magnifying glass as shown in Fig. 10.14? It is also a lens that helps in reading small print by making the letters appear bigger.

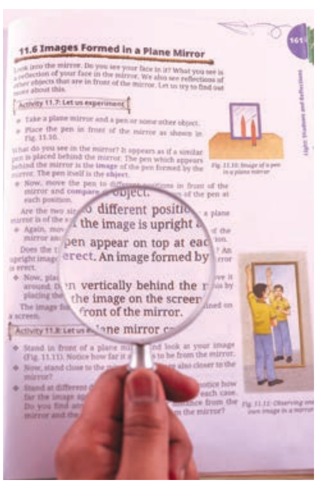



*Fig. 10.14: A magnifying glass*



A **lens** is a piece of transparent material, usually made of glass or plastic, which has curved surfaces. Like mirrors, lenses can also be convex or concave.

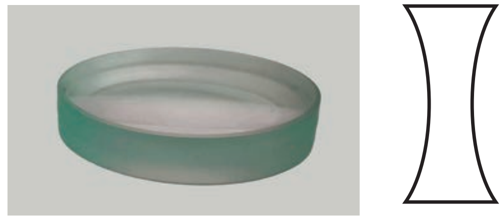
A lens which is thicker at the middle as compared to the edges is called a **convex lens** (Fig. 10.15a).

(a) (b)

*Fig. 10.15: (a) A convex lens; (b) Its representation*

A lens which is thicker at the edges as compared to the middle is called a **concave lens** (Fig. 10.16b).

Unlike mirrors, lenses allow light to pass through them, and we see things through a lens rather than in a lens.



(a) (b)

*Fig. 10.16: (a) A concave lens; (b) Its representation*

What changes can be seen in the objects when viewed through lenses?

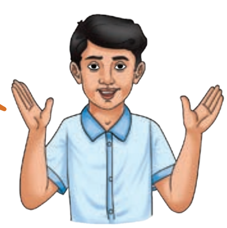
## Activity 10.9: Let us experiment

- Collect a convex lens, a concave lens, a lens holder, and a small object.
- Take the convex lens and place it upright using its holder.
- Place the object behind the convex lens (it may also be placed on something to bring it up to the level of the lens).
- Look at the object through the lens from the other side of the lens (Fig. 10.17a) and note your observations in your notebook.
- Now slowly move the object farther from the lens and keep observing how the image changes. How does the distance of the object from the convex lens affect how it looks?
- Now repeat the steps using a concave lens.
- Analyse your observations recorded in your notebook and **compare** the images seen through both lenses. What conclusions do you draw?

When an object is placed behind a convex lens at a small distance from it and seen through the lens, the object appears erect and enlarged in size. As the distance between the object and the convex lens increases, the object appears inverted. It is initially enlarged in size and then diminishes in size. An object placed behind a concave lens and seen through the lens, always appears erect and diminished in size. Its size changes, as its distance from the lens increases.

*Fig. 10.17: An object as seen through a (a) Convex lens placed at small distance; (b) Convex lens placed at large distance; (c) Concave lens*

Do lenses also converge or diverge the light beam?



## Activity 10.10: Let us investigate

- Collect a thin transparent glass plate, a convex lens, a concave lens, a torch and a comb to obtain multiple parallel beams of light, a paper clip to hold the comb upright, two identical books, and sheets of white paper.
- Using two books placed adjacent to each other, fix the glass plate or lens upright in between them as shown in Fig. 10.18. Spread paper sheets on both books.
- Now let the multiple parallel beams of light fall upon the thin glass plate, convex lens, and concave lens one by one as shown in Fig. 10.18. Does the parallel beam of light pass through as it is in all three cases?
- **Record** and analyse your observations.

The light beam passes through the thin glass plate as it is. The convex lens converges the light falling on it while the concave lens diverges the light. A convex lens is also called a **converging lens** while a concave lens is called a **diverging lens**.

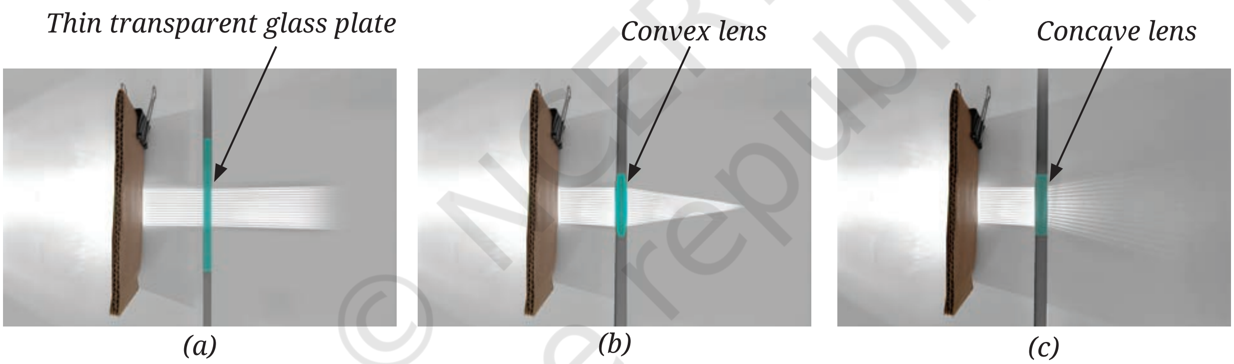
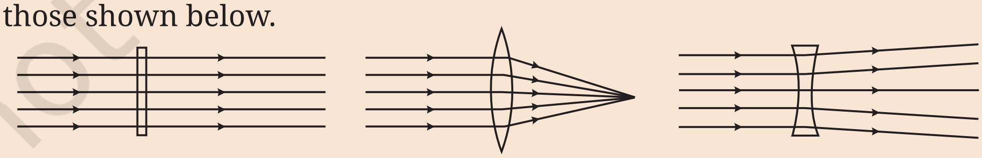



*Fig. 10.18: Multiple parallel beams of light fall upon the (a) Thin glass plate; (b) Convex lens; (c) Concave lens*

### A step further

If we draw what we observed in Activity 10.10, we get the figures like those shown below.



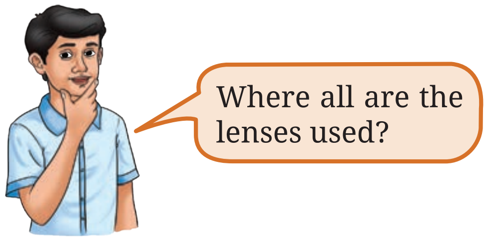
Since convex lens converges a light beam, can it also burn a paper?

## Activity 10.11: Let us investigate

- Repeat Activity 10.7 by putting a convex lens in the path of sunrays in place of a concave mirror. Could you burn the paper?

### Safety first

Do not look at the Sun directly or through the lens as it may damage your eyes.



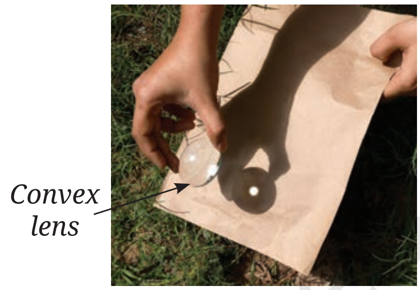




Fig. 10.19: Converging sunlight on paper using a convex lens

Lenses are important and are used everywhere around us. The eyeglasses that people wear to help them see clearly are lenses! Cameras, telescopes, and microscopes all use lenses to work. Even our eye has a convex lens inside it. It is quite an amazing lens that can change its shape, which is what allows us to read a book or see something far away.

(a) (b)

Fig. 10.20: (a) Eyeglasses; (b) Smartphone camera lenses

### Snapshots

- Image formed by a concave mirror can be enlarged, diminished or of the same size as the object, and it may be erect or inverted, depending upon the distance of the object from the mirror.
- Image formed by a convex mirror is always erect and diminished in size.
- Two laws of reflection are:
  - The angle of incidence is equal to the angle of reflection.
  - The incident ray, the normal to the mirror at the point of incidence, and the reflected ray, all lie in the same plane.
- The laws of reflection are valid for all kinds of mirrors—plane, concave, and convex.
- A concave mirror converges the light beams while a convex mirror diverges it.
- Image formed by a convex lens can be enlarged, diminished or of the same size as the object, and it may be erect or inverted, depending upon the distance of the object from the mirror.
- Image formed by a concave lens is always erect and diminished in size.
- A convex lens converges the light beams while a concave lens diverges it.

## Keep the curiosity alive

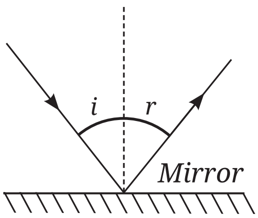


*Fig. 10.21*

1. A light ray is incident on a mirror and gets reflected by it (Fig. 10.21). The angle made by the incident ray with the normal to the mirror is 40°. What is the angle made by the reflected ray with the mirror?
   (i) 40°   (ii) 50°   (iii) 45°   (iv) 60°

2. Fig. 10.22 shows three different situations where a light ray falls on a mirror:
   (i) The light ray falls along the normal.
   (ii) The mirror is tilted, but the light ray still falls along the normal to the tilted surface.
   (iii) The mirror is tilted, and the light ray falls at an angle of 20° from the normal.

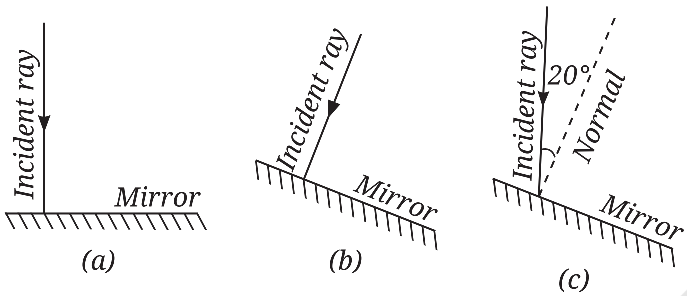


*Fig. 10.22*

   Draw the reflected ray in each case (Use a ruler and protractor for accurate drawing). What is the angle of reflection in each case?

3. In Fig. 10.23, the cap of a sketch pen is placed in front of three types of mirrors.

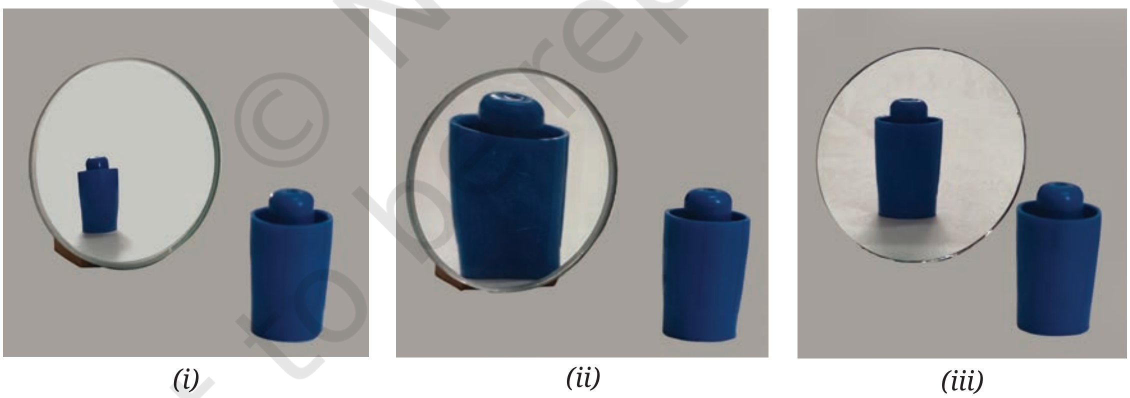


*Fig. 10.23*

   Match each image with the correct mirror.

| Image | Mirror |
|---|---|
| (i) | Plane mirror |
| (ii) | Convex mirror |
| (iii) | Concave mirror |

4. In Fig. 10.24 the cap of a sketch pen is placed behind a convex lens, a concave lens, and a flat transparent glass piece — all at the same distance.
   Match each image with the correct type of lens or glass.

*(i)* *(ii)* *(iii)*

*Fig. 10.24*

| Image | Lens/glass type |
|---|---|
| (i) | Flat transparent glass piece |
| (ii) | Convex lens |
| (iii) | Concave lens |

5. When the light is incident along the normal on the mirror, which of the following statements is true:
   (i) Angle of incidence is 90°
   (ii) Angle of incidence is 0°
   (iii) Angle of reflection is 90°
   (iv) No reflection of light takes place in this case

6. Three mirrors—plane, concave and convex are placed in Fig. 10.25. On the basis of the images of the graph sheet formed in the mirrors, identify the mirrors and write their names above the mirrors.

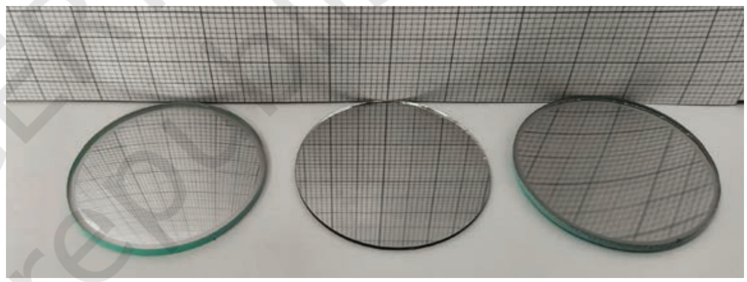


*Fig. 10.25*

7. In a museum, a woman walks towards a large convex mirror (Fig. 10.26). She will see that:
   (i) her erect image keeps decreasing in size.
   (ii) her inverted image keeps decreasing in size.
   (iii) her inverted image keeps increasing in size and eventually it becomes erect and magnified.
   (iv) her erect image keeps increasing in size.

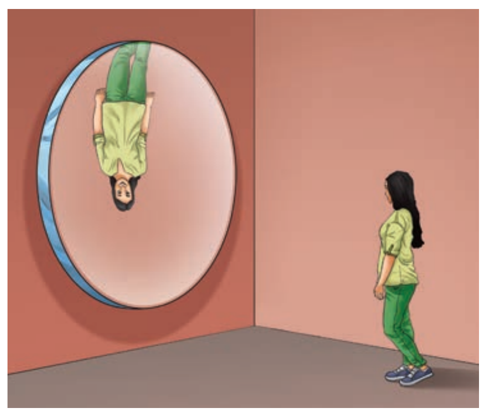


*Fig. 10.26*

8. Hold a magnifying glass over text and identify the distance where you can see the text bigger than they are written. Now move it away from the text. What do you notice? Which type of lens is a magnifying glass?

9. Match the entries in Column I with those in Column II.

| Column I | Column II |
|---|---|
| (i) Concave mirror | (a) Spherical mirror with a reflecting surface that curves inwards. |
| (ii) Convex mirror | (b) It forms an image which is always erect and diminished in size. |
| (iii) Convex lens | (c) Object placed behind it may appear inverted at some distance. |
| (iv) Concave lens | (d) Object placed behind it always appears diminished in size. |

10. The following question is based on Assertion/Reason.

**Assertion:** Convex mirrors are preferred for observing the traffic behind us.

**Reason:** Convex mirrors provide a significantly larger view area than plane mirrors.

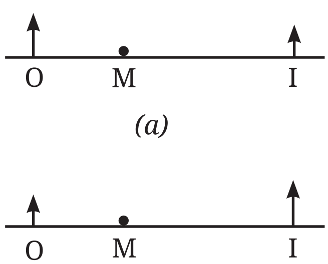
Choose the correct option:

(i) Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.

(ii) Both Assertion and Reason are correct but Reason is not the correct explanation for Assertion.

(iii) Assertion is correct but Reason is incorrect.

(iv) Both Assertion and Reason are incorrect.



*(a)*

*(b)*

*Fig. 10.27*

11. In Fig. 10.27, note that O stands for object, M for mirror, and I for image.

Which of the following statements is true?

(i) Figure (a) indicates a plane mirror and Figure (b) indicates a concave mirror.

(ii) Figure (a) indicates a convex mirror and Figure (b) indicates a concave mirror.

(iii) Figure (a) indicates a concave mirror and Figure (b) indicates a convex mirror.

(iv) Figure (a) indicates a plane mirror and Figure (b) indicates a convex mirror.




**Prepare some questions based on your learnings so far ...**

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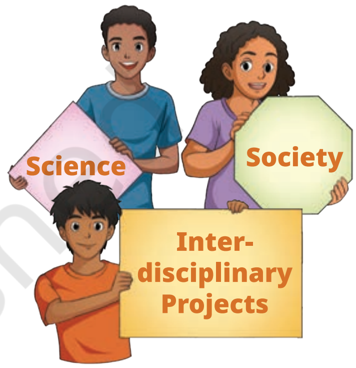
12. Place a pencil behind a transparent glass tumbler (Fig. 10.28a). Now fill the tumbler halfway with water (Fig. 10.28b). How does the pencil appear when viewed through the water? **Explain** why its shape appears changed.


*(a)* *(b)*

*Fig. 10.28*

## Discover, design, and debate




- Visit a nearby hospital or the clinic of an ENT specialist, or a dentist, with your teacher or parents. Request the doctor to show you the mirrors used for examining ear, nose, throat, and teeth. Identify the kind of mirror used in these instruments.

*Fig. 10.29*

- Harnessing sunlight is key to solving future energy challenges. In devices like solar cookers (Fig. 10.29), mirrors are used to converge sunlight and generate heat. In India, such designs are used in villages, thus saving electricity and reducing fossil fuel use. Think of a design for a solar cooker for your school or home and prepare a detailed proposal for it including the budget required.
- Use online tools or animation to do virtual experiments with spherical mirrors and lenses. Move objects in the simulation and observe how the image changes.

## Our scientific heritage

More than 800 years ago, during the time of the great Indian mathematician Bhāskara II, astronomers used shallow bowls of water to observe the stars and planets. By carefully looking at their reflected images through tubes placed at appropriate angles, they could measure the positions of stars and planets in the sky. Even though the laws of reflection are not mentioned in literature, their instruments and methods indicate that they might have understood it in practice!



**Reflect on the questions framed by your friends and try to answer ...**

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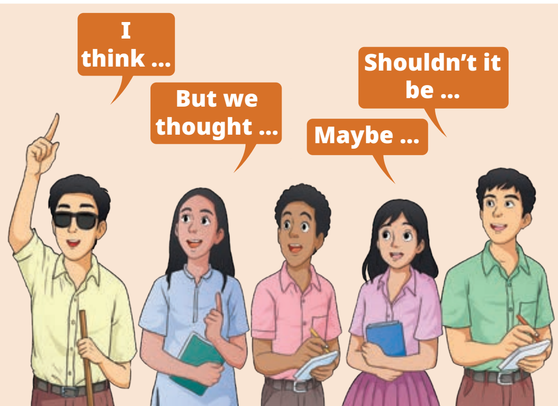


# Keeping Time with the Skies

# 11

0877CH11

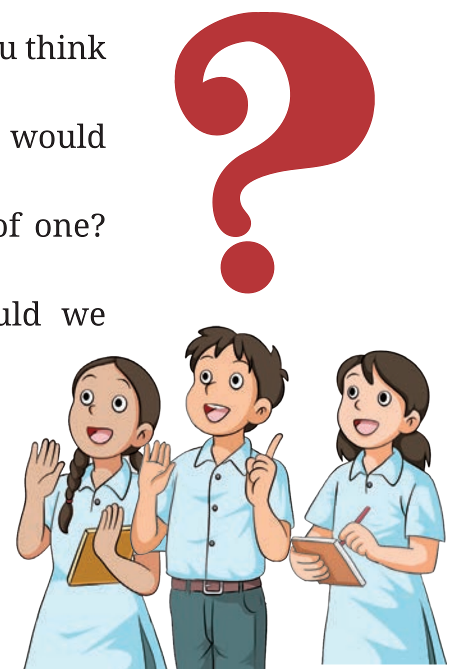


## Probe and ponder

- Have you ever seen the Moon during the day? Why do you think it is sometimes visible when the Sun is up?
- Imagine you lived on the Moon instead of Earth. What would you mean by a day, a month or a year?
- What would happen if Earth had two moons instead of one? How would that change the night sky?
- If we didn't have clocks or calendars, how else could we measure time?
- Share your questions

  ______________________________

  ______________________________?



It was Makar Sankranti, and Meera was in Ahmedabad for the *Patang Mahotsav*, the International Kite Festival. As she looked up at the sky filled with colourful kites, she noticed the Moon shining during the daytime. She was surprised as she had always thought the Moon appeared only at night. Also, the Moon did not appear like a full circle, but that didn't surprise her as much. She knew its shape changed every night. Still, it got her thinking. She remembered learning that the Moon is spherical and shines by reflecting sunlight. Then why isn't the whole Moon visible every night? For a moment, she wondered if it was due to a lunar eclipse. But eclipses are rare and brief. So, what causes the Moon's changing shape?

## 11.1 How Does the Moon's Appearance Change and Why?

Let us carefully **watch** the Moon to **understand** how its appearance changes over a month. You may have done a similar activity earlier, but let us now do it in more detail. Begin this activity from the sunrise after a full Moon day, that is when it is easiest to spot the Moon in the sky.

### Activity 11.1: Let us explore*

- **Spot** the Moon at sunrise in the western direction on the first day after the full Moon.
- Make a table similar to Table 11.1 in your notebook. Document the following:
  - Date
  - When you saw the Moon (at sunrise or sunset)?
  - Shade the corresponding Circle with pencil to show the bright portion of the Moon as shown in Fig. 11.1.
- From the second day onwards also document the following.
  - Is the size of bright portion of the Moon increasing or decreasing from the previous day.
  - Whether the Moon appears closer to or farther from the Sun in the sky than the day before.
- After about 15 days, you may not be able to see the Moon at sunrise or sunset. For the next 15 days, carry out this activity at sunset.

*Fig. 11.1: Shading the dark portion of the Moon*



* It is best to begin this activity a month or more before this chapter is scheduled to be learnt.

**Table 11.1: Documenting changes in the Moon's appearance**

| Day | Date | Moon seen at | Appearance of the Moon in the sky | Size of the bright portion compared to the previous day | Moon and Sun separation in the sky compared to the previous day |
|---|---|---|---|---|---|
| 1. | | Sunrise/Sunset | ○ | — | — |
| 2. | | Sunrise/Sunset | ○ | Increased/ Decreased | Closer/Farther |
| 3. | | Sunrise/Sunset | ○ | Increased/ Decreased | Closer/Farther |
| | | | | | |

**Analyse** the data recorded by you in Table 11.1. Did the Moon appear different each day? Was the Moon visible on all days? Did the Moon appear at the same position in the sky as on the previous day?

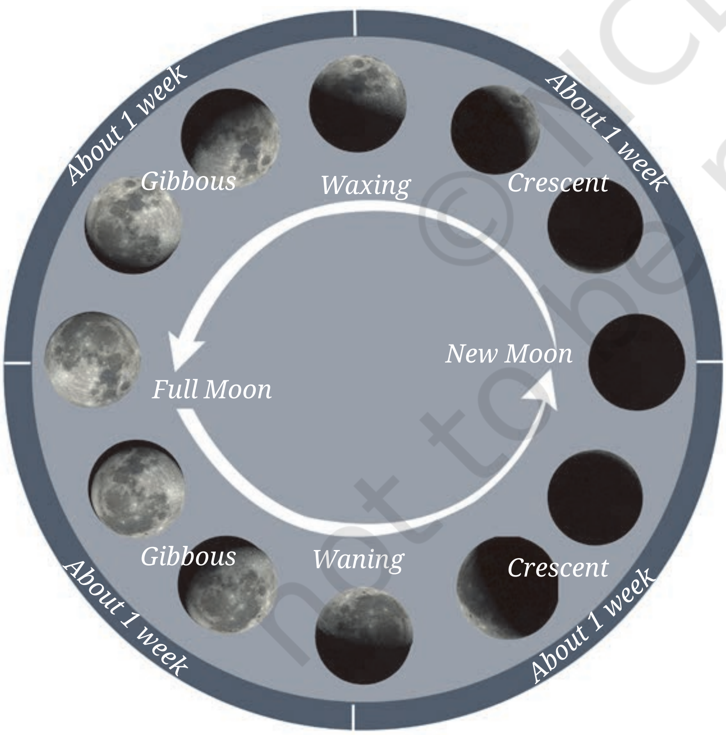



*Fig. 11.2: Waxing (Shukla Paksha) and waning period (Krishna Paksha) of the Moon as viewed from the Earth*

### 11.1.1 Phases of the Moon

You may have observed that the bright portion of the Moon decreases from a full circle to a half circle in about a week, as shown in Fig. 11.2. The bright portion continues to shrink for another week until it is no longer visible. This two-week period is called the **waning** period of the Moon. Different names are given to the Moon's visible shapes during this cycle (Fig. 11.2). The day when the Moon appears as a full bright circle is called the **full Moon** day (or *Purnima*), and the day when it is not visible is called the **new Moon** day (or *Amavasya*).

After the new Moon, its bright side grows to a half circle in about a week and to a full circle (full Moon) in another week. The period when the bright part of the Moon increases is called the

**waxing** period. In India, the waning period of the Moon is generally called the *Krishna Paksha*, while the waxing period is called the *Shukla Paksha*. The Moon goes through a waning period followed by a waxing period in a cyclical manner as shown in Fig. 11.2. The cycle from one full Moon to the next takes about a month.

The changing shapes of the bright portion of the Moon from one day to another as seen from the Earth are called the **phases of the Moon**.

### 11.1.2 Locating the Moon

When you checked the Moon at the same time on successive days (for example, at sunrise), did you see it in a different part of the sky? On a full Moon day, the Moon is nearly opposite the Sun—when the Sun rises in the East, the Moon is almost setting in the West. On subsequent mornings at sunrise, as its bright part continues to decrease, the Moon appears to move closer in the sky to the Sun. When the bright part of the Moon decreases to a half circle shape, the Moon is overhead at Sunrise. A few days later, the crescent Moon appears even closer to the Sun. Knowing the phase of the Moon and whether it is waxing or waning can thus help us find out where and when to look for the Moon on any given day. A waxing Moon is easiest to spot at sunset, and a waning Moon at sunrise. Because of these shifts, the Moon always rises and sets at different times than the Sun.

#### A step further

Many people believe the Moon rises when the Sun sets, but that is not always true. Look in a local newspaper or on the Positional Astronomy Centre (India Meteorological Department) website to find the moonrise time in your area. Check these times for several days in a row and you will see that the Moon rises about 50 minutes later each day. Sometimes moonrise happens in the afternoon (around 2:00–4:00 p.m.), so you can spot the Moon in the eastern sky during daylight. You may need to wait about 30 minutes past the listed moonrise time for the Moon to climb high enough for it to be seen.


*The time and position of moonrise changes from one day to the next.*

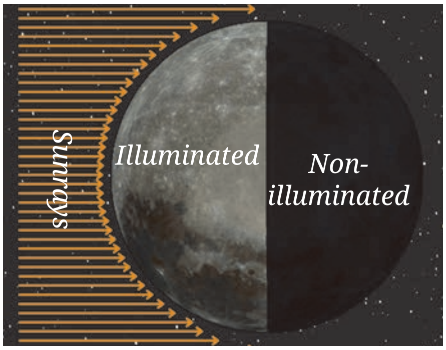
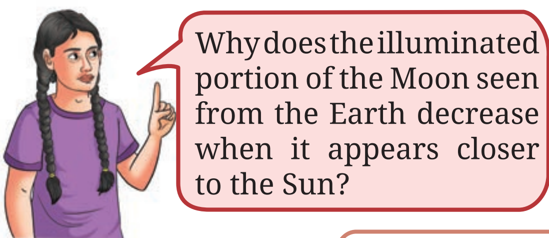



*Fig. 11.3: Sunlight falling on the Moon*

### 11.1.3 Making sense of our observations

The shape of the Moon itself does not change, only what we see changes. You may recall learning earlier that the Moon does not emit light of its own, but shines because it reflects sunlight that falls on it. The half of the Moon that faces the Sun receives sunlight and becomes illuminated (Fig. 11.3). The other half facing away from the Sun does not receive sunlight and remains non-illuminated.

The Moon revolves around the Earth and, only one half of the Moon always faces the Earth. However, the portion of the Moon facing the Earth is not always its illuminated part. We can only see the illuminated portion of the Moon from Earth. Sometimes, the entire illuminated portion of the Moon faces the Earth, and at other times only a part of it. At such times the illuminated portion of the Moon that we see is not a full circle. On New Moon day, we do not see the illuminated portion of the Moon at all, as only the non-illuminated portion of the Moon faces the Earth. Therefore, the Moon appears different on different days.




Let us do an activity to understand how the illuminated portion of the Moon, as seen by us, changes when its position changes with respect to the Sun.

## Activity 11.2: Let us explore

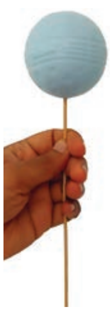
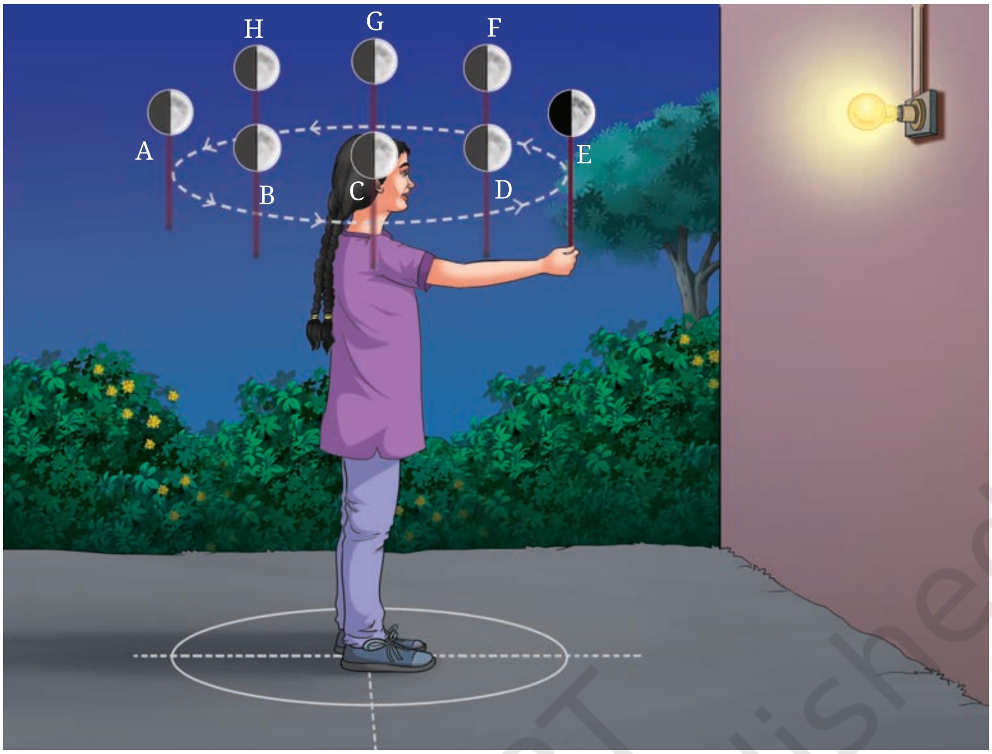


*Fig. 11.4: (a) Ball with stick*

- Take a small soft ball and insert a stick into it (Fig. 11.4a). This represents the Moon.
- Go to a dark open place (at night), and ask a teacher or guardian to shine a torchlight towards you from about 3 m to represent light coming from the Sun or stand near an electric lamp. Your head represents the Earth.
- Now hold the ball at arm's length in one hand such that it is slightly above your head as shown in Fig. 11.4b. Keep the ball at position E towards the direction of the lamp. Does the portion of the ball facing you appear to be illuminated or not?
- Turn around slowly, in the anti-clockwise direction, with your arm outstretched as shown in Fig. 11.4b and keep looking at the ball. Does the shape of the illuminated portion change? Is the line separating the illuminated and non-illuminated portions of the ball curved?
- Was your observation similar to the changing shape of the illuminated portion of ball shown in Fig. 11.4c? The shape of the illuminated portion of the ball, as seen by you, changes depending on where the ball is with respect to the lamp.




(b)


(c)

*Fig. 11.4: (b) A student using a ball and stick to understand phases of Moon; (c) The ball as seen by the student at different positions*

When the ball is held opposite to the direction of the lamp (at A), you are facing the entire illuminated portion of the ball, just like the full Moon day. On the other hand, when the ball is held towards the direction of the lamp (at E), you are facing the non-illuminated portion of the ball, and cannot see the illuminated portion of the ball at all. This is similar to the new Moon day. Notice how in other cases, the line separating the illuminated and non-illuminated portions of the ball appears curved (Fig. 11.4c), similar to the shape of the illuminated portion of the Moon viewed from the Earth on other days.

Using our observations of Activity 11.2, let us now try to understand the phases of Moon. Fig. 11.5a shows the positions of the Moon corresponding to the different positions of the ball in Fig. 11.4b. Also shown are the Earth and the sunrays. As shown in Fig. 11.5a, the Moon revolves once around the Earth from position A to H and back to position A in about one month. The side of the Moon that faces the Sun is illuminated.

The portion of the Moon that faces the Earth is marked by the orange dashed lines and arrows. The illuminated portion of only this part of the Moon can be seen from the Earth. At positions B and H, more than half of the illuminated portion, called the **gibbous phase**, can be seen. At positions D and F, less than half of the illuminated portion, called the **crescent phase**, can be seen. The change in the fraction of the illuminated portion of the Moon seen from Earth causes phases of the Moon.

The phases that will be seen from the Earth at different positions of the Moon are shown in Fig. 11.5b. From A to C to E, we see the waning phase, and from E to G and back to A, we see the waxing phase. Since the rotation period of the Earth of one day is much smaller compared to the revolution period of the Moon which is nearly a month, on a given day, people on different parts of the Earth see nearly the same phase.

As can be seen in Fig. 11.5a, on the New Moon day, the Moon appears closest to the Sun and it appears farthest on the Full Moon day. Is this not what we also observed in Activity 11.1?

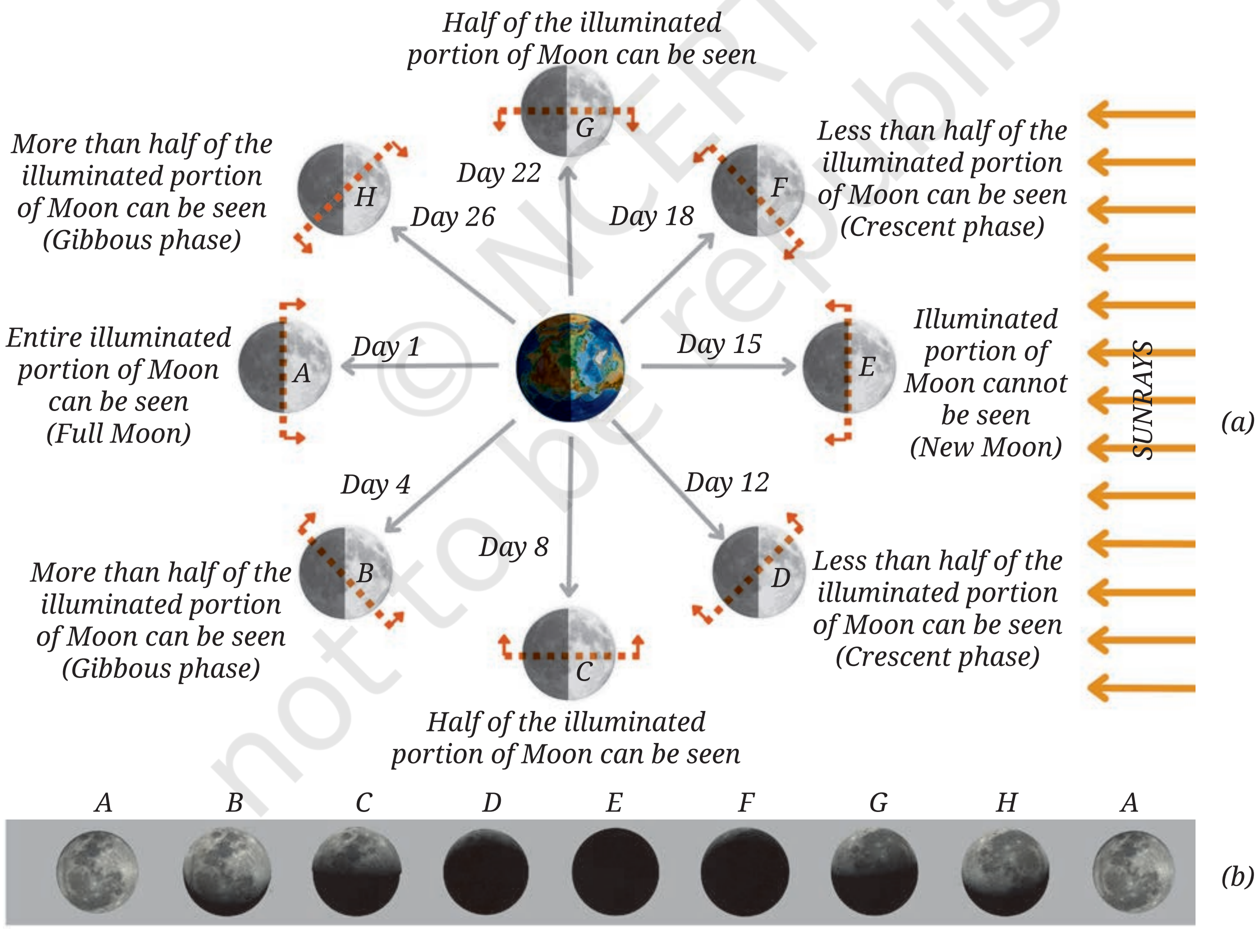



*Fig. 11.5: (a) The Moon at different positions in its orbit around the Earth; (b) The corresponding phases of the Moon as seen from the Earth. (The sizes and the distances are not to scale in this figure.)*

In Activity 11.1, we also observed that the position of the Moon at sunrise (or sunset) appeared to be shifted on successive days. This happens because, as shown in Fig. 11.6, the Moon moves ahead in its orbit while the Earth completes one rotation about its axis in 24 hours. Earth needs to rotate some more for the Moon to appear in nearly the same spot in the sky.

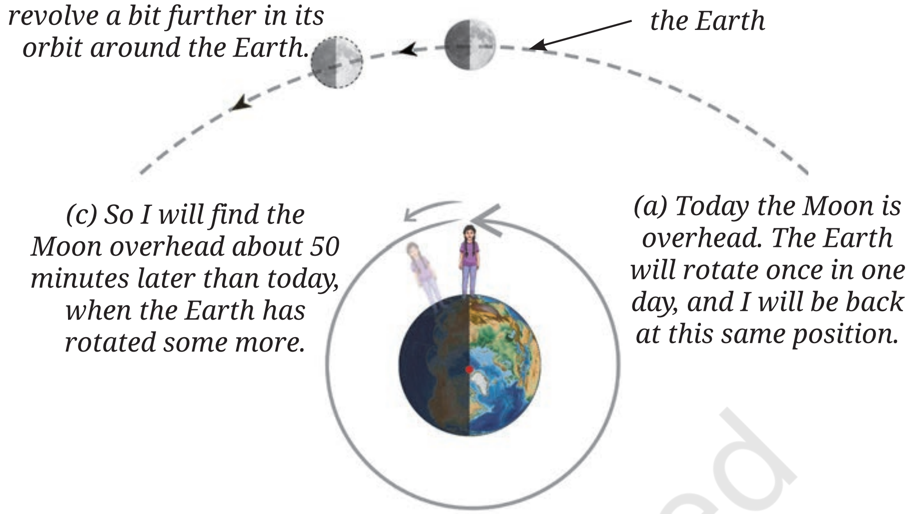
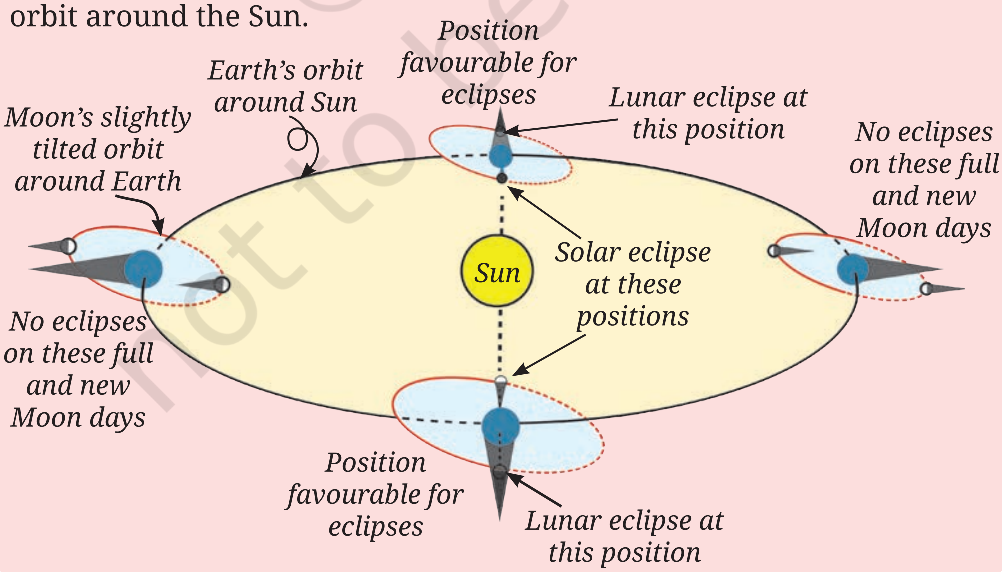



*Fig. 11.6: The Moon takes about 50 minutes longer to come back to nearly the same position in the sky.*

## A step further

The Moon phases do not happen due to Earth's shadow. It is an incorrect explanation for the Moon's phases that Earth's shadow falls on it. As we have learnt, the phases of the Moon occur due to the relative change in orientation of the Sun, Moon, and Earth as the Moon revolves around the Earth. The Earth's shadow on the Moon causes a lunar eclipse, not the Moon's phases as we learnt earlier (in chapter 'Earth, Moon and the Sun' in the *Curiosity*, Grade 7).

Lunar eclipses can only happen on a full Moon day and solar eclipses can happen only on a new Moon day. But they do not occur every month because of the small tilt of the Moon's orbit with respect to the Earth's orbit around the Sun.




So, changing phases of the Moon is a natural periodic event, with a cycle of almost a month, which can also be used for time keeping.

Yes, along with the natural periodic events of day and night and the changing seasons about which we learnt earlier. But how are these periodic events used for keeping time?

## 11.2 How Did Calendars Come into Existence?

We have learnt earlier that when viewed from the Earth, the Sun appears to rise in the eastward direction, set in the westward direction every day, and rise again the next day. This apparent periodic motion of the Sun seen by us is primarily due to the rotation of the Earth around its own axis. This natural cycle of the Sun due to the rotation of the Earth, is the foundation of the day, a unit to measure time.

The average time that the Sun takes to go from its highest position in the sky on one day to the highest position in the sky the next day, is 24 hours, and is called the **mean solar day**. The highest position of the Sun in the sky can be found by measuring the length of the shadows cast by an object during the day. The shadow is shortest when the Sun is at the highest point in the sky.



### Activity 11.3: Let us measure a day!

- Find a small flat area in a ground which receives sunlight during the day. Fix a 1 m stick vertically in it as shown in Fig. 11.7.

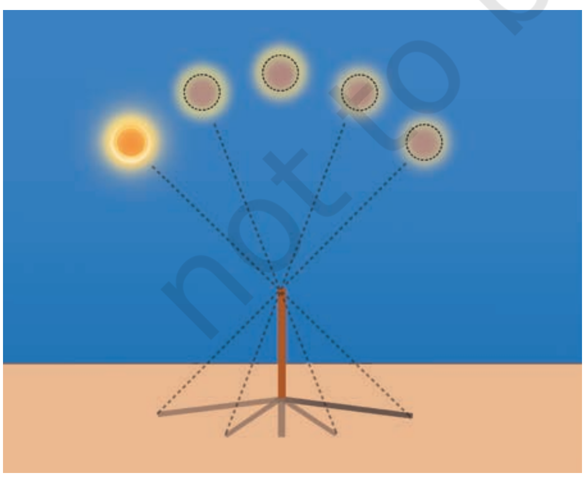


*Fig. 11.7: Observing the length of the shadow at different times during the day.*

- Start observing at 11:00 a.m. Every minute, mark a dot on the ground at the tip of the stick's shadow. Keep marking dots until around 1:10 p.m.
- **Identify** when the shadow was shortest and find out its time by counting the number of dots. **Record** this time in Table 11.2. Repeat this exercise for the next few days.
- Find the duration of the solar day by finding a difference in time on two consecutive days as shown in Table 11.1.

**Table 11.2: Finding the duration of a solar day**

| Date | Time of shortest shadow (hh:mm) | Duration of day (hh:mm) |
|---|---|---|
| 22 March 2025 | 12:20 | —— |
| 23 March 2025 | 12:20 | 24:00 |
| 24 March 2025 | 12:19 | 23:59 |
| | | |

Find the average duration of the day. Is it nearly equal to 24 hours?

The phases of the Moon give us another natural cycle with a duration that is longer than a day. The Moon takes about 29.5 days (nearly a month) to cycle through all its phases. The cycle of the phases of the Moon is the basis for a **month**, another unit to measure time (Fig. 11.8).

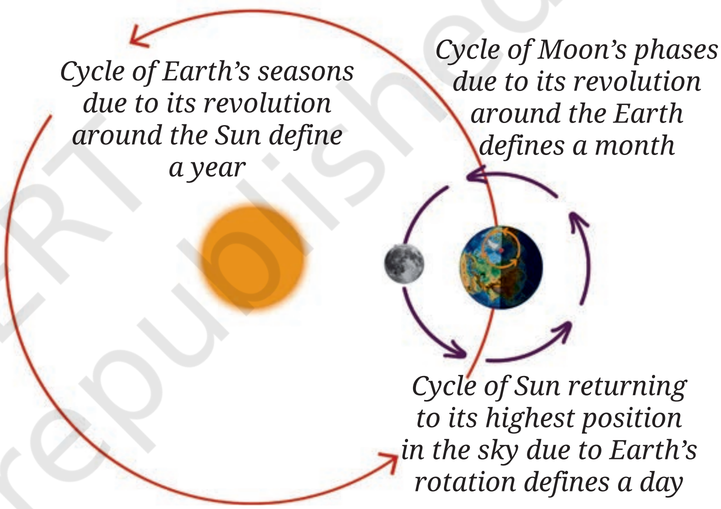


*Fig. 11.8: The Earth goes around the Sun, and the Moon revolves around the Earth in regular intervals of time.*

The next larger unit to measure time is related to the natural cycle of seasons. Do you remember learning earlier that the Earth revolves around the Sun and takes nearly 365 and a quarter days to complete one revolution around the Sun? The Earth undergoes one cycle of seasons during this time, which can be used to define a **solar year** (Fig. 11.8).

### 11.2.1 Lunar calendars

In ancient times, people had noticed that during one cycle of seasons, one can fit nearly 12 cycles of the phases of the moon, that is, 12 lunar months. This is how **lunar calendars** came into being, with the day as the shortest unit, a month of nearly 29.5 days, and a lunar year consisting of 12 lunar months. The phases of the Moon thus gave an easy and a perfectly sound way to track the passage of time.

However, in a lunar calendar the seasons do not remain synchronised to the same lunar months in successive lunar years. The reason is that the seasons repeat in approximately 365 days while the lunar year is 354 days long.

### 11.2.2 Solar calendars

It was important to know the arrival of seasons for agricultural purposes. This need for a year to synchronise with seasons led to the creation of **solar calendars**. The Gregorian calendar, widely used today, is a solar calendar. The months in solar calendars are adjusted to add up to 365 days. That is why in Gregorian calendars, some months have 30 days, others 31, and February has only 28 days.

On top of the 365 days, the Earth takes nearly an extra quarter of a day to complete one revolution around the Sun. These extra hours add up to approximately one day every four years. To adjust for this, solar calendars add an extra day every four years using the concept of a **leap year**. In the Gregorian calendar, if a year is divisible by four, then an extra leap day is added. So in a leap year, February has 29 days, which keeps the calendar well synchronised with the seasons.

**A step further**

The Earth takes slightly less time than 365 and a quarter day to go from one spring equinox to the next spring equinox. Adding a day every four years helps to synchronise with the seasons, but it actually adds a little too much over time. To fix this, leap years are skipped every 100 years—like in 1700, 1800, and 1900. But skipping all of them would make the calendar lag slightly behind. So every 400 years, a leap year is again added back—like in 1600 and 2000. These careful corrections keep the calendar closely matched with the seasons over long periods of time!

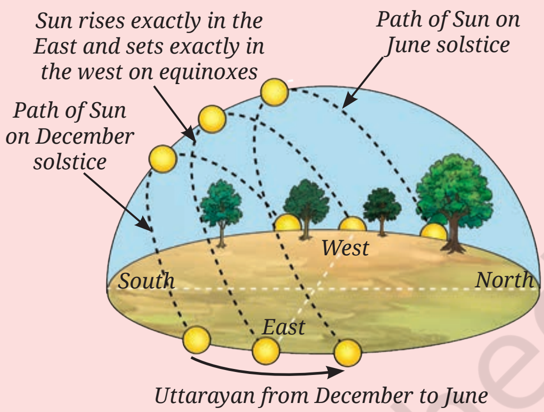
**A step further**

As we learnt earlier, seasons are caused by the Earth's revolution around the Sun and its movement from the spring equinox to winter equinox and back. The time between successive spring equinoxes is called the tropical year. Gregorian calendar is based upon tropical year.

We have also learnt earlier that the stars that rise at sunset change throughout the year due to the Earth's revolution around the Sun. The time duration required for the same stars to rise again at sunset is called the sidereal year, and it can also be used to define a solar calendar. The sidereal year is longer than the tropical year by a mere 20 minutes, and so it takes a long time before the differences between the two calendars become noticeable. In modern times, astronomers use the sidereal year to keep track of the Earth's position in its orbit around the Sun.

## Our scientific heritage

For thousands of years, people—including those in India—have been observing the sky and developing calendars. People in ancient times did not know that Earth revolves around the Sun, and lacked modern instruments. Yet through years of careful sky observations, they noticed patterns and cycles in natural events. Hence, they could determine that the length of the year was approximately 365 days allowing them to create calendars.




For example, careful observation reveals that the Sun does not always rise exactly in the East. In summer, it rises a little northward of East and in winter a little southward of East. These extremes happen on the solstices, around June 21 and December 21 each year. The Sun's apparent northward movement from December to June is called *Uttarayan*, and its apparent southward movement from June to December is *Dakshinayan*. This cycle repeats every year and is closely linked to the changing seasons. The *Taittirīya Saṁhitā* records it in the verse 6.5.3:

तस्मादादित्यः षण्मासा दक्षिणेनैति षडुत्तरेण ।

"Thus the Sun moves southwards for six months and northwards for six months."

In the past, the equinoxes and solstices were also tracked by identifying the stars that rose at sunset. Ancient Indian texts like the *Surya Siddhanta* noted that the pattern of stars, Capricorn (called *Makar* in India), would be in the background of the Sun around the winter solstice during those ancient times.

भानोर्मकरसंसङ्क्रान्तेः षण्मासा उत्तरायणम् ।

कर्क्कादेस्तु तथैव स्यात् षण्मासा दक्षिणायनम् ।।9।।

Translation: From the moment of the Sun's entrance into the constellation of Capricorn, six months make up its northward progress (*Uttarayana*), so likewise from the moment of entrance into the constellation of Cancer, six months are its southward progress (*Dakshinayana*).

Over the years, different types of calendars have evolved based on specific needs. A number of these calendars are used in different parts of India to track time and celebrating festivals.

### 11.2.3 Luni-solar calendars

There is another kind of calendar which primarily uses the Moon's phases for counting days and months but also make adjustments to stay in sync with the cycle of seasons.

The 12 lunar months add up to 354 days and thus fall short by nearly 11 days compared to the solar year. Thus every 2–3 years, the accumulated difference becomes close to a full month. Therefore, every few years, an extra month (called *Adhika Maasa* or intercalary month) is added to the year in some calendars. This keeps the solar year and the lunar cycle in step. Such calendars are called **luni-solar calendars**. They combine elements from both the solar and the lunar calendars and are used in many parts of India.

**Ever heard of ...**

You may have heard of the names (or similar sounding names) of the months in various Indian luni-solar calendars—*Chaitra, Vaisakha, Jyeshtha, Ashadha, Shravana, Bhadrapada, Ashwin, Kartika, Margashirsha (or Agrahayan), Pausha, Magha, and Phalguna*. In some communities, the new month starts on the first day after the new Moon and ends on the day of the new Moon. Such calendars are called *Amant*. In others, the start of the new month corresponds to the day after the full Moon, and the month ends on the full Moon. Such calendars are called *Purnimant*.

### 11.2.4 The Indian National Calendar

A national calendar by the Government of India is used along with Gregorian calendar for multiple official purposes.

**Shaka Era 1947**

**Chaitra**
(March 22 - April 20, 2025)

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| रवि | सोम | मंगल | बुध | गुरू | शुक्र | शनि |
| | | | | | | MAR 1 22 |
| 2 23 | 3 24 | 4 25 | 5 26 | 6 27 | 7 28 | 8 29 |
| 9 30 | 10 31 | APR 11 1 | 12 2 | 13 3 | 14 4 | 15 5 |
| 16 6 | 17 8 | 18 7 | 19 9 | 20 10 | 21 11 | 22 12 |
| 23 13 | 24 15 | 25 14 | 26 16 | 27 17 | 28 18 | 29 19 |
| 30 20 | | | | | | |

**Vaisakha**
(April 21 - May 21, 2025)

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| रवि | सोम | मंगल | बुध | गुरू | शुक्र | शनि |
| | APR 1 21 | 2 22 | 3 23 | 4 24 | 5 25 | 6 26 |
| 7 27 | 8 28 | 9 29 | 10 30 | MAY 11 1 | 12 2 | 13 3 |
| 14 4 | 15 5 | 16 6 | 17 7 | 18 8 | 19 9 | 20 10 |
| 21 11 | 22 12 | 23 13 | 24 14 | 25 15 | 26 16 | 27 17 |
| 28 18 | 29 19 | 30 20 | 31 21 | | | |
| | | | | | | |

**Jyestha**
(May 22 - June 21, 2025)

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| रवि | सोम | मंगल | बुध | गुरू | शुक्र | शनि |
| | | | | MAY 1 22 | 2 23 | 3 24 |
| 4 25 | 5 26 | 6 27 | 7 28 | 8 29 | 9 30 | 10 31 |
| JUN 11 1 | 12 2 | 13 3 | 14 4 | 15 5 | 16 6 | 17 7 |
| 18 8 | 19 9 | 20 10 | 21 11 | 22 12 | 23 13 | 24 14 |
| 25 15 | 26 16 | 27 17 | 28 18 | 29 19 | 30 20 | 31 21 |
| | | | | | | |

*Fig. 11.9: Indian National Calendar*

It is a solar calendar (Fig. 11.9) consisting of 365 days in a year. The year begins on 22 March, which is the day after the spring equinox. Unlike the Gregorian calendar, months in the Indian National Calendar have either 30 or 31 days. The names of these months were taken from traditional Indian calendars. In a regular year, the second to sixth months have 31 days and the rest have 30 days. The leap years are matched to the Gregorian calendar by adding a day to Chaitra, the first month of the year. In such years, the new year begins on 21 March of the Gregorian calendar.

### Ever heard of ...

In 1952, the Government of India set up a Calendar Reform Committee (CRC) to examine all existing calendars which were being followed in the country at that time and to recommend an accurate and uniform calendar for the whole of India. The CRC recommended 'Unified National Calendar' was adopted for use with effect from 21 March 1956 CE, that is, 1 Chaitra 1878 Saka. The Indian National Calendar follows the general principles as that of the *Surya Siddhanta*.

### Be a scientist

**Meghnad Saha (1893–1956)**
Meghnad Saha was a pioneering astrophysicist of India who studied stars and their temperatures and developed a mathematical equation, famously known as the Saha equation. The Saha Institute of Nuclear Physics, in Kolkata, is named after him. He was also the chairperson of the Calendar Reform Committee.

## 11.3 Are Festivals Related to Astronomical Phenomena?

Why do most Indian festivals fall on different dates every year?

Many Indian festivals are tied to the phases of the Moon and hence are based on either lunar or luni-solar calendars. For instance, *Diwali* falls on the new Moon of the month of *Kartika*, *Holi* on the full Moon of *Phalguna*, *Buddha Purnima* on the full Moon of *Vaisakha*, *Eid-ul-Fitr* is celebrated after sighting the crescent Moon at the end of the month of *Ramazan*, while *Dussehra* is celebrated on the tenth day in the month of *Ashwina*. Hence, they occur on different dates in the Gregorian calendar in successive years.

For festivals based on luni-solar calendars, the Gregorian calendar dates can shift, but this shift is typically less than a month. This is because the luni-solar calendars add the intercalary month every few years which correct for the difference between the lunar and the solar year. In contrast, purely lunar calendars do not account for this difference. Any festival celebrated according to the phases of the Moon, such as *Eid-ul-fitr*, therefore can occur in different months of the Gregorian calendar year after year.

## A step further

A few festivals in India, like *Makar Sankranti*, *Pongal*, *Bihu*, *Vaisakhi*, *Poila Baisakh*, and *Puthandu*, follow a solar sidereal calendar. These festivals happen on almost the same date every year in the Gregorian calendar which is based on the tropical year.

A long time ago, these festivals were tied to either a solstice or an equinox. Due to the small difference in the sidereal and tropical years, the dates of these festivals slowly shift away from the solstices/equinoxes. This shift is due to slow wobble of the Earth's axis, similar to the movement of the axis of a wobbling top.

This causes the dates of festivals based on the sidereal calendar to move ahead in tropical calendar. For example, *Makar Sankranti* moves ahead by one day every 71 years.

## Ever heard of ...

The dates of many Indian festivals are based on the exact lunar phase at sunrise. As sunrise occurs earlier in Eastern India and later in Western India, these dates can also shift by a day between these regions even in the same year. To maintain uniformity throughout the country, the Positional Astronomy Center of the Government of India annually publishes the Rashtriya panchang, a detailed calculation of the positions of celestial objects, such as the Moon and the Sun for a central location in India. Based on these calculations, it provides an advance intimation on dates of festivals to Government of India for holiday declaration.



## Ever heard of ...

The Moon and moonlight have inspired ragas in Indian classical music. *Chandrakauns*, *Chandranandan*, and *Shubhapantuvarali* (which also means "auspicious moon") are a few ragas that display the moon's imagery in their names and melodic expressions. Similarly, mudras (hand gestures), for example, *Chandrakala*, and *Ardhachandran* relating to the Moon can be found in Indian classical dance Bharatanatyam.

The same is true for other dance forms—Kathak, Odissi, and Kuchipudi. Even the traditional painting styles: Madhubani, Warli, and other forms of art, such as sculpture and pottery among Saura, Gond and other tribes invoke depictions of the Moon and the Sun prominently implying their significance in daily life.

*Warli painting*

*Dhokra Brass sculpture*

## 11.4 Why Do We Launch Artificial Satellites in Space?

The Moon is Earth's natural satellite, orbiting our planet. Besides the Moon, man-made satellites sent by various countries also orbit the Earth. These **artificial satellites** appear as tiny specks moving in the night sky. Most orbit about 800 km above Earth's surface and take roughly 100 minutes to complete one orbit.

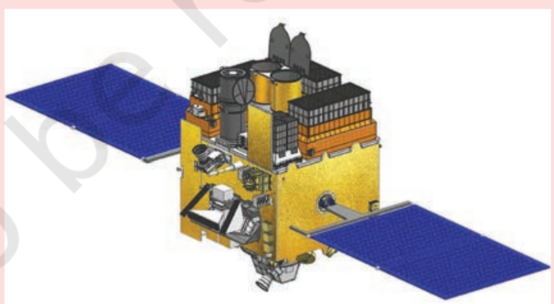

These satellites help us in many ways like communication, navigation, weather monitoring, disaster management, and scientific research. The Indian Space Research Organisation (ISRO) has launched many satellites that support these activities.

### Our scientific heritage

The Cartosat series of satellites, launched by ISRO, capture high-quality images of the Earth to improve maps, plan cities, and handle natural disasters in India. One such mapping platform, Bhuvan, uses these images to show terrain, soil, land use, vegetation, and more.

AstroSat, another ISRO mission, makes scientific observations of stars and other celestial objects. India's other space missions include Chandrayaan 1, 2, and 3 to the Moon; Aditya L1 to study the Sun; and Mangalyaan to Mars. ISRO also lets Indian students build and launch small satellites, such as AzaadiSat, InspireSat-1, and Jugnu.

*Cartosat*



*AstroSat*

## Activity 11.4: Let us identify

- Spotting an artificial satellite is a night sky watching activity like we have done previously. Just before sunrise or after sunset, go to a location, accompanied by an adult, that has a clear view of the sky, without any obstruction of trees or tall buildings.

- To identify satellites in the sky, look for any moving object in the sky that appears as a point of light with steady or flickering brightness and is moving very fast across the sky. You can see them with the naked eye or with binoculars.
- You may use mobile apps or websites that provide details of satellites visible in your location and when they will be passing above you in the sky.

## A step further

A lot of artificial satellites are being sent up in space by many countries. After their useful life, many of them and their rocket parts become space junk or space debris. This debris crowds space, and could collide with working satellites. While small debris burns up in the atmosphere when it falls towards the Earth, the larger pieces can crash on ground. Countries are now working together to remove this dangerous debris.

## Be a scientist

**Vikram Ambalal Sarabhai (1919–1971)**

Vikram Sarabhai, a researcher in space science and nuclear physics is known as the Father of the Indian Space programme. He pioneered the effort to launch the first artificial satellites. The Vikram Sarabhai Space Centre (VSSC), located in Thiruvananthapuram, the ISRO centre that develops rockets and launch vehicle technology, is named after him.



## Snapshots

- The illuminated part of the Moon changes its shape from day to day through phases, like the new Moon, crescent, and full Moon.
- The phases of the Moon happen because we see different parts of the illuminated portion of the Moon as it moves around the Earth.
- A full cycle of phases of the Moon takes about a month.
- The various cycles observed in nature resulted in the creation of calendars.
- Lunar calendars follow the Moon's cycle, while solar calendars follow the cycle of seasons, which depend upon the position of the Earth in its orbit around the Sun. Luni-solar calendars adapt to both the cycles.
- Artificial satellites are human-made which are launched from the Earth. They provide important information for our well-being and space-science studies.

## Keep the curiosity alive

1. State whether the following statements are True or False.
   (i) We can only see that part of the Moon which reflects sunlight towards us.
   (ii) The shadow of Earth blocks sunlight from reaching the Moon causing phases.
   (iii) Calendars are based on various astronomical cycles which repeat in a predictable manner.
   (iv) The Moon can only be seen at night.

2. Amol was born on 6th of May on a full Moon day. Does his birthday fall on the full Moon day every year? Explain your answer.

3. Name two things that are incorrect in Fig. 11.10.

*Fig. 11.10*

4. Look at the pictures of the Moon in Fig. 11.11, and answer the following questions.


*Fig. 11.11*

   (i) Write the correct panel number corresponding to the phases of the Moon shown in the pictures above.

| Picture label (e.g. A, B, C, etc.) | Phase of Moon |
|---|---|
| | Three days after New Moon |
| | Full Moon |
| | Three days after Full Moon |
| | A week after Full Moon |
| | Day of New Moon |

   (ii) List the picture labels of the phases of the Moon that are never seen from Earth. Hint: You can use your observations from Activity 11.1 or Fig. 11.2 as reference.

5. Malini saw the Moon overhead in the sky at sunset.
   (i) **Draw** the phase of the Moon that Malini saw.
   (ii) Is the Moon in the waxing or the waning phase?

6. Ravi said, “I saw a crescent Moon, and it was rising in the East, when the Sun was setting.” Kaushalya said, “Once I saw the gibbous Moon during the afternoon in the East.” Who out of the two is telling the truth?
7. Scientific studies show that the Moon is getting farther away from the Earth and slower in its revolution. Will luni-solar calendars need an intercalary month more often or less often?
8. A total of 37 full Moons happen during 3 years in a solar calendar. Show that at least two of the 37 full moons must happen during the same month of the solar calendar.
9. On a particular night, Vaishali saw the Moon in the sky from sunset to sunrise. What phase of the Moon would she have noticed?
10. If we stopped having leap years, in approximately how many years would the Indian Independence day happen in winter?
11. What is the purpose of launching artificial satellites?
12. On which periodic phenomenon are the following measures of time based: (i) day (ii) month (iii) year?

## Discover, design, and debate

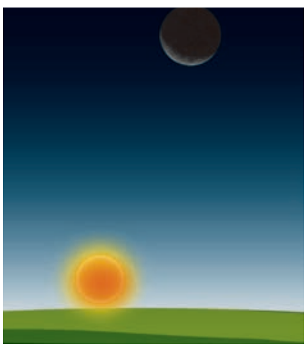


*Fig. 11.12*

- The Moon’s crescent always faces towards the Sun (Fig. 11.12). On days when you see the crescent Moon, point your finger towards the Sun, and slowly move it across the sky towards the Moon taking as short a path as you can. Note how your finger always crosses the illuminated part of the Moon first and clearly shows us that we see sunlight reflected off the Moon. The line joining the tips of the crescent would correspond to the diameter of the Moon.
- Most of the dates in the Indian National Calendar always map to the same dates in the Gregorian calendar. Can you find out which ones may differ for certain years?
- Different states in India celebrate the New Year according to their local cultures. **Find** out the names of the New Year festival celebrated in any 10 states of India. Also find out whether it is




**Prepare some questions based on your learnings so far ...**

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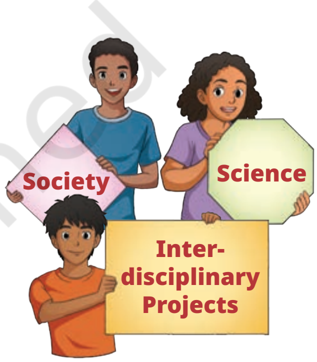
based on the lunar calendar or the solar calendar or the luni-solar calendar.

- Collect Gregorian calendars (the regular calendar you use every day) for the last five years with the help of your family members or teachers or the internet. For each year, look for the dates on which the festivals *Eid-ul-Fitr* and *Diwali* were celebrated and list them year wise in a tabular form. Do you notice that the date of *Eid-ul-Fitr* moves earlier each year — by about 11 days? If you have a corresponding lunar calendar at home or on the internet, **check** that the month and the day for *Eid-ul-Fitr* according to the lunar calendar remains the same. Does *Diwali* follow the same steady pattern, or are there some sudden jumps? Based on your chart, try to guess which year might have included an intercalary month (*Adhikamaasa*). Obtain a luni-solar calendar and **confirm** if there is an intercalary month between *Diwali* in the previous year and that year.




- Every morning on your way to school, notice the direction in which the Sun rises. Decide on a spot and look towards east, with trees, poles, or buildings acting as markers. **Sketch** the eastern horizon in your notebook. For the next one year, at the start of each month, stand at the same spot and mark the Sun's position on your sketch. **Label** it with the name of the month. At the end of the year analyse your sketch. Do you find that the positions of sunrise shift in particular direction? Can you identify it with the *Uttarayaan* and *Dakshinayaan* that our ancestors noticed? (Refer the 'A step further' box on page 181).

## A step further

If you visit a place near the sea, you may notice that water levels rise and fall. The rise and fall of water levels are called tides. Tides also follow a regular pattern. If there's a low or a high tide at a certain time on one day, a similar tide will come about 50 minutes later the next day. We also learnt that the Moon also rises about 50 minutes later each day. Careful observations show that tide levels are closely related to the Moon's position and phase.

**Reflect on the questions framed by your friends and try to answer ...**

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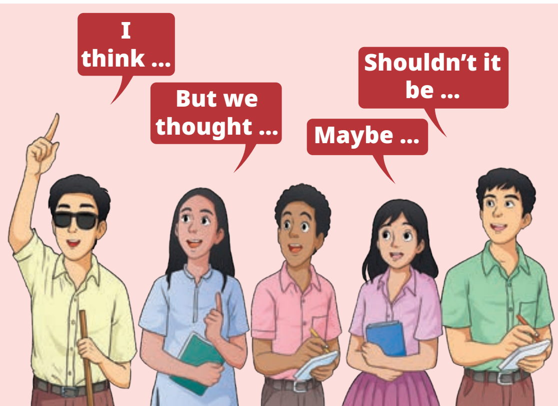
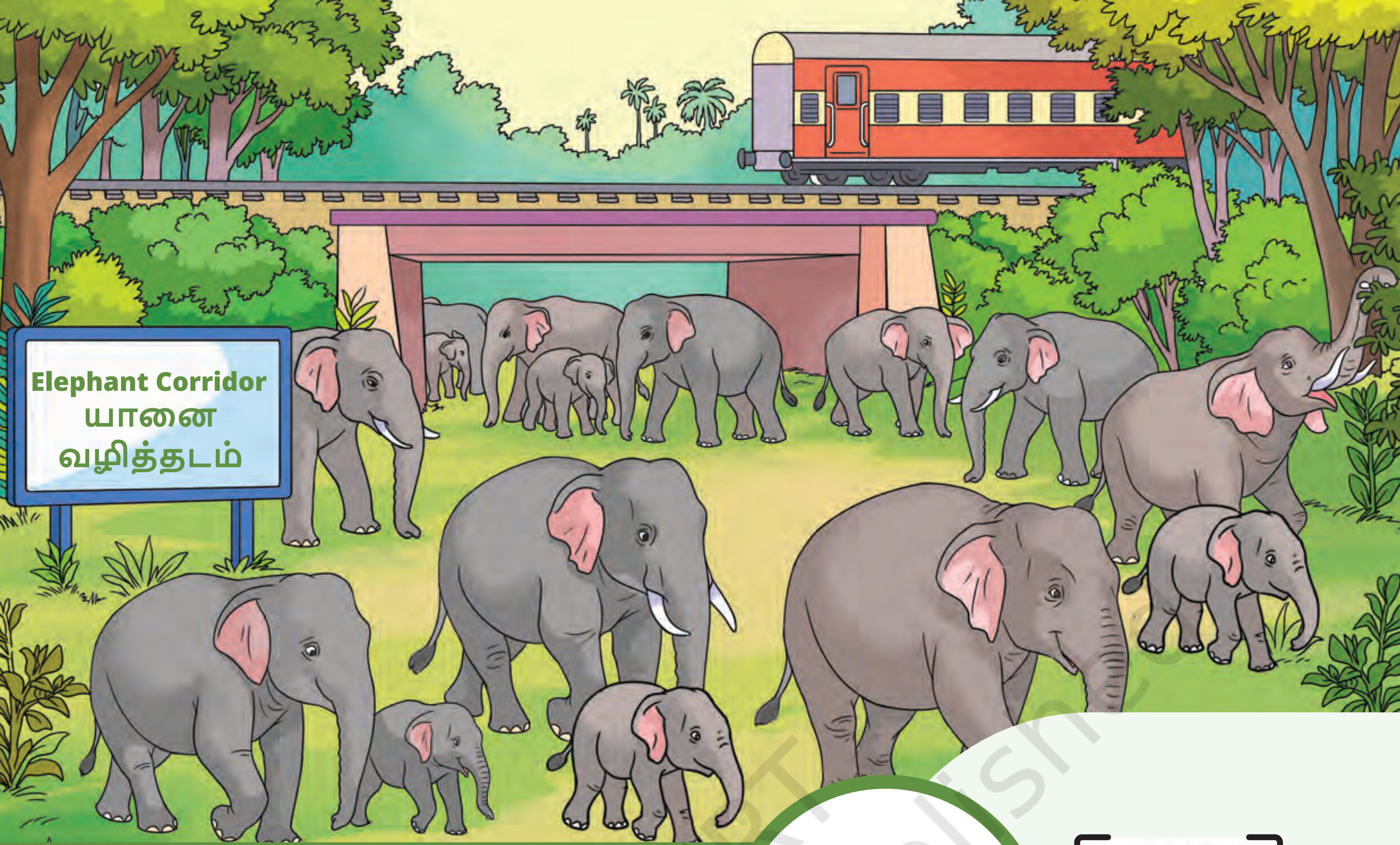





# 12 How Nature Works in Harmony



## Probe and ponder

- How might the loss of forest cover and changes in rainfall patterns lead to elephants to enter human farms and villages?
- Imagine you are a tree in a dense forest. What kind of relationships would you have with water, sunlight, other animals, and other components of the forest?
- Do you think the Earth can thrive without humans? Can humans survive without the earth?
- If two kinds of birds compete for the same fruit, how might their way of living change over time?
- Can human actions cause natural disasters?
- Share your questions

  ______________________________

  ______________________________?

In several parts of India, particularly in states like Odisha, Jharkhand, West Bengal, Assam, and Chhattisgarh, elephants often enter farms and villages. When vegetation is scarce and waterholes dry up in their natural habitat, elephants may wander in to nearby farms or plantations in search of food like bananas and sugarcane. This can lead to in crop damage and at times, even harm people and domestic animals.

Changes in rainfall and temperature affect vegetation. Cutting down trees for constructing roads and buildings makes it worse. This leads to the shrinking and drying of forests, the natural home of animals. When forests cannot support wildlife, animals tend to move into human habitats. Elephants are adapted to forest life, but sudden changes make it hard for them to survive. Wildlife ecologists have identified and marked corridors in many parts of the country to allow safe movement of animals. These corridors correct forest habitats, enabling wildlife—such as elephants to travel in need between large forest areas without coming into conflict with human settlements.

This chain of events shows how closely nature's elements are connected. To understand such interconnections, we must study the components of our environment.

## 12.1 How Do We Experience and Interpret Our Surroundings?

You have learnt in *Curiosity*, Grade 6 chapter 'Diversity in the Living World' that different habitats have different kinds of plants and animals. A habitat is simply place where an organism lives. It could even be just the bark of a tree. The plants and animals interact with each other and adapt to survive in the surrounding conditions they live in. **Explore** two nearby habitats and **identify** both the living organisms and the non-living components in each.

### Activity 12.1: Let us explore

*Caution*: Explore the habitat in groups with your teacher.

- Identify two habitats in your surroundings.
- These could be any two of the following: a pond, a forest, an agricultural farm, or even a large tree like banyan, mango, or *pilkhan* (white fig) tree.
- List the living beings and non-living things that you **observe** in these habitats.
- **Record** your observations in Table 12.1.

**Table 12.1: Different components of two habitats**

| Pond | | Forest | |
|---|---|---|---|
| Living beings | Non-living things | Living beings | Non-living things |
| Fish | Water | Plants | Soil |
| | | Grass | |
| | | Trees | |
| | | Birds | |

*(a) Pond habitat*

*(b) Forest habitat*

*Fig. 12.1: Two types of habitats*

What common characteristics do you observe in the two habitats in Activity 12.1? The similarities are that both habitats have living beings as well as non-living things. However, the types of living beings are different and the non-living things also vary. The living beings you have recorded in Table 12.1 are termed as the **biotic** components and non-living things as the **abiotic** components of a habitat. Have you wondered why some organisms live on land while others live in water? Every organism needs specific conditions to survive. From this activity, you can see that different habitats offer different living conditions.

In Activity 12.1, you listed fish as a biotic component of the pond. How do fish survive in a pond? A pond provides food, oxygen, shelter, and space to grow—conditions essential for survival of organisms. Fish obtain their biotic needs, such as food, from small plants and animals, and abiotic needs, such as oxygen, from water.

Other living beings also inhabit the pond, such as frogs, fresh turtles, snakes, dragonflies, mosquitos, snails, and ducks, along with plants like algae, diatoms, duckweeds, and lotus. They all interact with the other living beings and non-living things present in the places where they grow and thrive.

Each habitat has its own biotic components and physical conditions—air, sunlight, water, temperature, and soil. Different organisms living in the same habitat may use the resources in different ways. A forest might be warm during the day and cool at night. A snake that comes out at night and a rodent active during the day both live in the same habitat, but they face different conditions. This is how living organisms coexist in harmony in the same habitat.

## 12.2 Who All Live Together in Nature?

You have observed fish in a pond in Activity 12.1. Did you see only a single fish? Most likely, you may have seen many fish of the same kind. This group of fish of the same kind living together in a pond habitat is called a **population** of that particular fish. In this way, we can observe and record populations of different kinds of organisms in a single habitat.

### Activity 12.2: Let us record

We can understand the population of a particular type of plant by counting them at a given place and time.

- Divide students into four to five groups.
- Each group may identify any two organisms, plant(s) or animal(s).
- Mark an area of 1 m × 1 m in your school garden.
- Identify four organisms in this area, and count their numbers.
- Record the number of the organisms in Table 12.2.
- Compile the data from all groups.

**Table 12.2: Number of particular organisms at a given space and time**

| Name of organism | Population (Number of individual organisms) |
|---|---|
| Plant 1: ____________ | 20 |
| Plant 2 : ____________ | 05 |
| Animal 1 : ____________ | |
| Animal 2 : ____________ | |

In the given example, there is a population of 20 ______ plants and is only 5 ______ plants in the same $1 \times 1$ $m^2$ area.

From Activity 12.2, we can explain that the population is a group of the same type of organisms in a habitat at a given time.

Can a habitat have only one type of living organism? What might happen then? If all organisms are the same, they would have the same requirements—food, water, space—leading to competition and possible scarcity of resources. What else do you think could happen?

In Activities 12.1 and 12.2, you observed that different group of organisms live together in a habitat. A **community** comprises different populations sharing the same habitat. The biotic components of a habitat, such as the plants, animals, and microorganisms together form the community. These organisms interact and depend on one another for survival.

### Ever heard of ...

You may have seen brightly coloured flowers blooming around you. Have you ever looked closely at their parts? A flower has a stalk, green leafy structures called **sepals**, coloured **petals** and two reproductive parts. **Carpels** (female) and stamens (male). Stamens burst release yellow dust like **pollen grains**. Wind, ‘water insects, bats and birds helps carry pollen from the stamens to the carpels of the same and different flowers. This process is called **pollination** (Fig.12.2). It is essential for the formation of fruits and seeds.

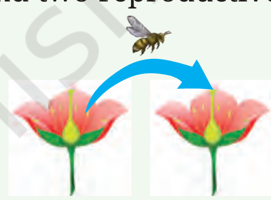


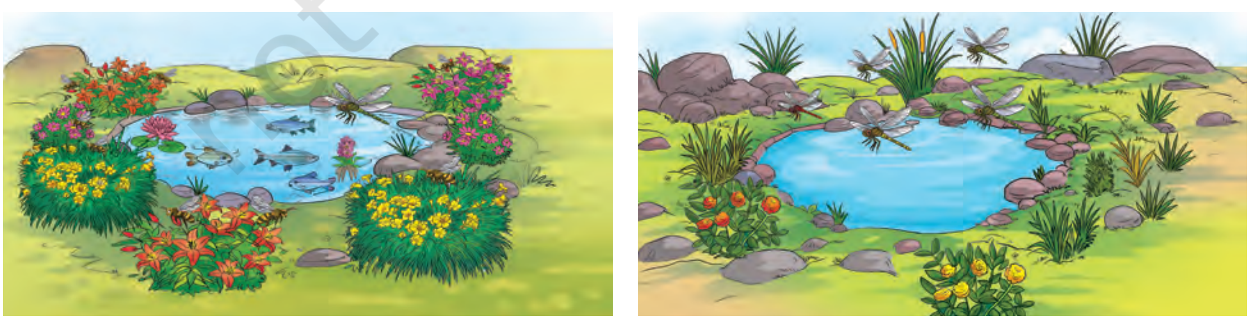
*Fig. 12.2: Insect pollination*

## 12.3 Does Every Organism in a Community Matter?

Let us find out the role of different organisms in a community.

### Activity 12.3: Let us read

- Researchers **conducted** a study to see how fish in ponds affect seed production in the plants nearby. They observed



*Pond A* *Pond B*

*Fig. 12.3: Pond A with fish and Pond B without fish*

two ponds—A with fish and large number of flowering plants around it; B without fish and fewer flowering plants around it (Fig. 12.3). Think of a reason for these observations.

- **Compare** the number of dragonflies, bees, and butterflies in both the ponds. Do you find any relationship between the number of dragonflies and bees/butterflies? We observed that in Pond A (with fish) the number of dragonflies were less as compared to Pond B. Why?

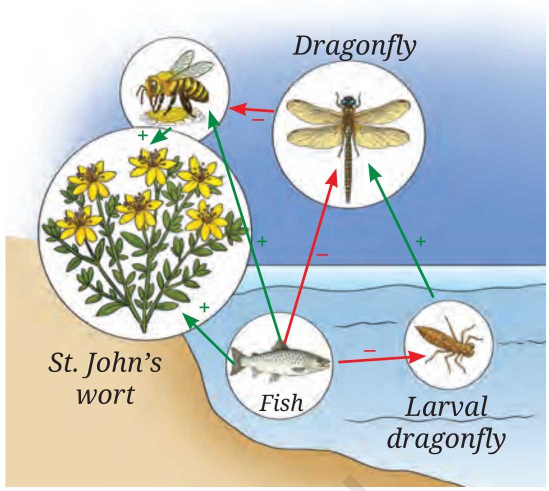



*Fig. 12.4: Fish have indirect effect on plants in and around ponds. The solid arrows represent the direct effect, and the dashed arrows represent the indirect effect*

- Fish eat dragonfly larvae, so ponds with fish had fewer dragonflies. Dragonflies usually eat flies, bees and butterflies With fewer dragonflies, more bees, flies, and butterflies were found. These insects help pollinate flowers from nearby areas moving pollen from one flower to another, which helps plants produce seeds. So, flowers near ponds with fish may produce more seeds than those near ponds without fish.
- What does this study show? How does the population of fish in a pond affect the seed production in nearby plants?
- This study shows how biotic components (fish, dragonflies, pollinators, plants) and abiotic components (temperature, water, nutrients) interact with and affect each other (Fig. 12.4). Similarly, can overfishing by humans change this balance? How do you think it may affect the living and non-living parts of the habitat?

## 12.4 What Are the Different Types of Interactions Among Organisms and their Surroundings?

In *Curiosity*, Grade 7, you learn about how plants and animals need air, water, soil, and sunlight to grow. Living organisms, or the biotic community, depend on non-living things, that is abiotic components for their survival. Plants and animals also depend on each other for nutrition, respiration, and reproduction. These are interactions among the biotic components. Both types of interactions—among biotic components, and between biotic and abiotic components—are important for survival in any habitat.

*Fig. 12.5: Biotic and abiotic interactions*

Look at Fig. 12.5, and try to identify interactions among biotic components, and between biotic and abiotic components based on your learnings till now.

## Activity 12.4: Let us relate and identify

- Based on the given criteria, **identify** and **describe** the interactions between biotic and abiotic components shown in Fig. 12.5.

  **Criterion 1**

  Interactions between abiotic and biotic components. These may influence life processes like nutrition, respiration, and reproduction in biotic components.

  **Criterion 2**

  Interaction between two abiotic components these may influence the physical characteristics of a habitat.

  **Criterion 3**

  Interaction among the biotic components. These may influence the availability of resources needed for life processes like nutrition, respiration, and reproduction.

- **Relate** your learning with your observations.
- Record your observations in Table 12.3 at the appropriate places. Table 12.3 is filled with examples for your reference.

**Table 12.3: Interaction of biotic and abiotic components in a habitat**

| Criterion 1: Interactions between biotic and abiotic components | Criterion 2: Interaction between two abiotic components | Criterion 3: Interaction among the biotic components |
|---|---|---|
| Earthworms live in moist soil. | The day temperature is high due to the bright sunlight. | A frog eats insects. |
| Many microbes are present in the pond. | Water is evaporating fast due to the sunlight. | A water snake eats fish. |
| A fish lays eggs in water. | Air current is blowing slowly on the water surface creating gentle waves. | Frogs and fish may compete for small insects larvae. |
| | The soil near the pond is moist. | A fish lays eggs in water near vegetation to protect them from other fish or frogs. |

In Activity 12.4, you understood different types of interactions occur within a habitat. From this, you can infer that the biotic components (plants, animals, and microorganisms) and the abiotic components (air, water, soil, sunlight, and temperature) in a habitat interact with each other to form an **ecosystem**. Organisms in an ecosystem interact with abiotic components for food, shelter, and protection in an ecosystem. Different communities of living organisms interact with abiotic components in an ecosystems. There are two main types of ecosystems in nature. **Aquatic ecosystems** include ponds, rivers, and lakes while **terrestrial ecosystems** include forests, farms or even large trees like banyan, mango, or *pilkhan*. Hence, ecosystems can be large or small. Can you find overlapping ecosystems in Fig. 12.6?

*Fig. 12.6: Overlap of terrestrial and aquatic ecosystems*

Fig. 12.6 shows an overlap of different terrestrial and aquatic ecosystems. In this figure, you can see a small river (an aquatic ecosystem) along with mountains, forests, grassland, and farmland, which are examples of terrestrial ecosystems. Farmland is a **human-made ecosystem**. These ecosystems are interacting with each other at any given point.

In Activity 12.4, we have seen the importance of the components and their interactions in an ecosystem. For example, sunlight, carbon dioxide, and water are essential for producing food in plants; soil provides medium and essential nutrients for plant growth; air provides oxygen for respiration in plants as well as animals; water is essential for all living organisms. This shows how living organisms depend on the non-living component of an ecosystem.

Just as biotic components depend on abiotic components, abiotic components also depend on biotic components. For example, plants release oxygen during photosynthesis, roots hold soil in place and prevent erosion, and plants retain soil moisture and help cool the atmosphere.

You can identify and study any ecosystem in your surroundings and observe different types of interactions among the biotic and abiotic components. While studying biotic interactions, notice how organisms depend on each other for food.

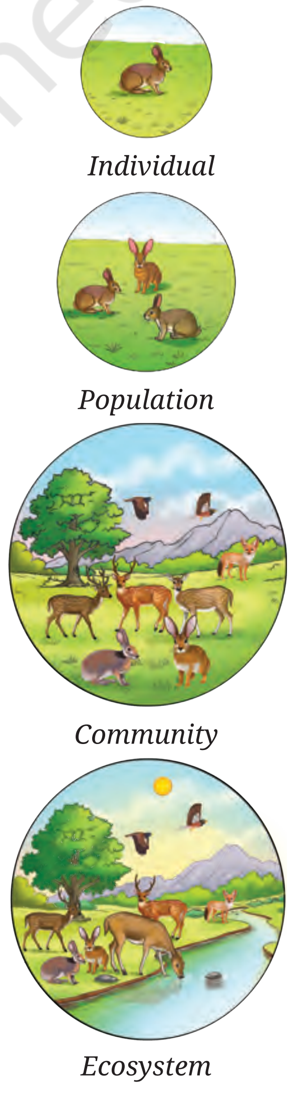



*Fig. 12.7: Individual to ecosystem*

## Activity 12.5: Let us classify

Observe Fig 12.1b, which illustrates a forest ecosystem.

- Study the picture carefully and spot the organisms listed in Table 12.4.

- Using the internet or your school library, find out what do these organisms eat.
- Record your observations in Table 12.4 by identifying whether each organism feeds only on plants and plant products, only on animals, or on both.

**Table 12.4: Eating habits of different organisms**

| Name of the organism | Performs photosynthesis | Feeds on plants and plant products | Feeds on animals | Feeds on both plants and/or animals |
|---|---|---|---|---|
| Deer | No | Grass and leaves of plants | No | Only on plants |
| Horse | | | | |
| Vulture | | | | |
| Bengal Fox | | | | |
| Bird (*Shikra*) | | | | |
| Squirrel | | | | |
| Mouse | | | | |
| Mushroom | | | | |
| Tree | Yes | | | |

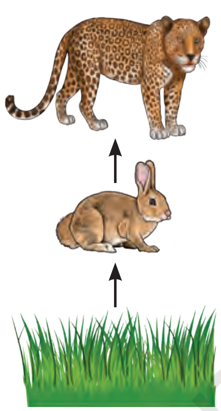


*Fig. 12.8: Food chain*

How do plants get their food? As you know, plants make their own food by the process of photosynthesis. Thus, they are called **producers** or **autotrophs** (*auto*=self + *troph*=food).

Organisms that cannot produce their own food and depend on other organisms for their food are called **consumers** or **heterotrophs** (*hetero* = other + *troph* = food). List the heterotrophs from Table 12.4.

Organisms that eat only plants are called **herbivores**, such as deer and hare. Those that eat only animals are **carnivores**, such as leopard. Organisms that eat both plants and animals are **omnivores**, such as crows, foxes, and mice.

## 12.5 Who Eats Whom?

In Activity 12.5, we learn about the feeding relationship among organisms. How can we make linkages with the feeding relationship among organisms in a given ecosystem?

## Activity 12.6: Let us link (relate)

- Take an example of a grassland ecosystem.
- Consider the following organisms that we can spot in a grassland ecosystem: grass, frog, hare, fox, grasshopper, snake, and eagle.
- In Fig. 12.8, a relationship of who eats whom is shown among some of the organisms.
- **Draw** the feeding relationships for the remaining organisms by adding arrows, similar to those in Fig. 12.8.

In Fig 12.8, you can see that the grass is eaten by the hare and the hare is eaten by the fox. This is a representation of a food chain in a grassland ecosystem. Which is another food chain that can be drawn for the organisms given in this activity? One example may be as follows:

Grass ⟶ Grasshopper ⟶ Frog ⟶ Snake ⟶ Eagle

The interactions between biotic components based on feeding relationships can be represented in the form of a linear chain. A **food chain** is a simple sequence showing 'who eats whom' in an ecosystem. One such example is given in Fig. 12.9.

*Fig. 12.9: Another food chain in a grassland*

## Activity 12.7: Let us draw

Fig. 12.10a represents a crop field with millets, mouse, and eagle.

- **Count** the number of each type of organism in Fig. 12.10a.
- Make a table and set a number in the table against each of the organisms.
- Arrange the numbers in the ascending order, consider the highest number at the base and the lowest at the top.
- Place the mouse, millet, and eagle appropriately in Fig. 12.10b.
- What figure do you get? It looks like a pyramid. Complete the pyramid in Fig. 12.10b.

*Fig. 12.10: (a) Food chain of millet, mouse, and eagle in a crop field*

Each organism in a food chain has a specific position, called a **trophic level** (*troph* = food):

- Producers (like green plants) are at the first trophic level.

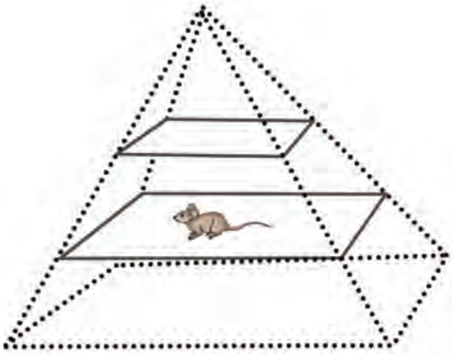


Fig. 12.10: (b) Food chain represented in a pyramid

- Herbivores (like hares and deer) are at the second level.
- Small carnivores (like frogs) are at the third level.
- Large carnivores (like tigers or vultures) occupy the next level.

## Activity 12.8: Let us trace and link

- Look at Fig. 12.11.
- Look at the figure and put more arrows for the missing relationship of 'who eats whom'.
- How many other organisms might be connected to one organism through a feeding relationship in an ecosystem?

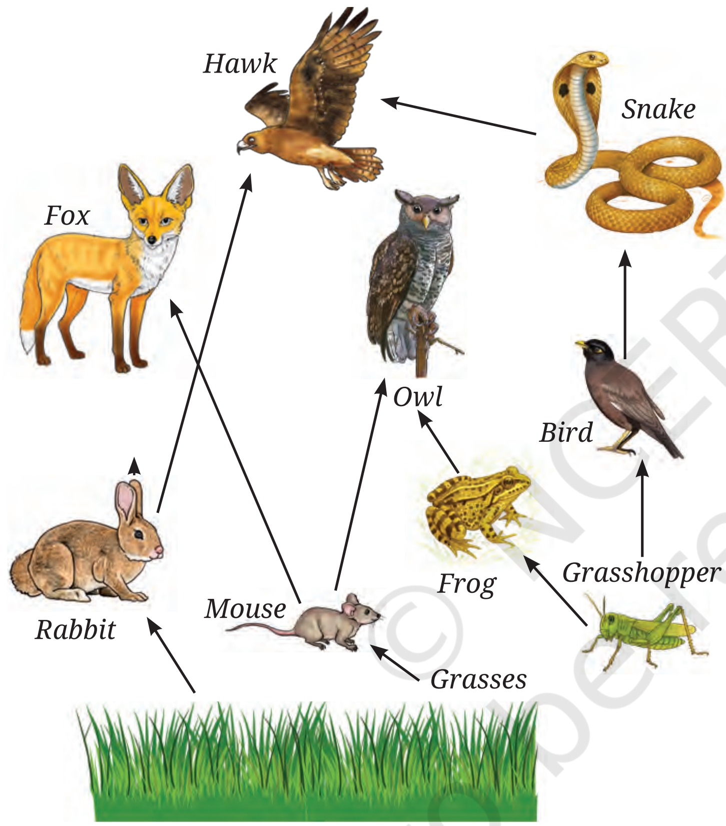



Fig. 12.11: Food web

Look at Fig. 12.11, and observe the relationship between different food chains in an ecosystem. Are these food chains interlinked? Each of the organisms may be eaten by two or more types of organisms. Thus, in an ecosystem, the food chains are interlinked with each other to form a network, called a **food web**.

You know that living organisms grow, perform many functions, develop, and die. During their life cycle, organisms produce a lot of waste, including dead matter and food waste.

Fig. 12.12: Mushroom growing on dead organic matter

## 12.6 What Happens to Waste in Nature?

You may have seen small umbrella-like structures, mushrooms, growing on dead plants or trees during the rainy season (Fig. 12.12). These are a type of fungi that grow on dead matter. Microorganisms like fungi and bacteria break down complex substances in dead plants and animals into simpler ones. This process returns important nutrients to the soil. You can also find tiny insects, such as beetles and flies, on animal droppings—like elephant dung—as they help break it down and recycle nutrients, back into the environment. This process is called **decomposition** and the organisms carrying out the process are called **decomposers** or **saprotrophs** (*sapro*= rotten + *trophs* = food). Plants grow in soil and many of the nutrients in soil come from the decomposition process. Thus, decomposers play an important role in recycling nutrients. In nature, nothing is wasted—everything is reused. Does nature really waste anything?

## Ever heard of ...

India is a country with diverse habitats and seasons. Many **migratory birds** fly thousands of miles and reach different habitats in India. They migrate from different parts of the world to avoid harsh climate, and in search for food. Birds not only enhance the aesthetics of those habitats but also play a significant role in keeping the balance in an ecosystem as **pollinators** or seed dispersers along the path they migrate. This way they link two habitats. These birds are **predators** of insect pests and help farmers to control pest populations, and indirectly help in healthy crop growth. Migratory birds, Demoiselle Crane visit the water body of Khichan village in Jodhpur district during the winter months. Do you know which birds in your area are seen only during winter? **Collect** postal stamps and covers of migratory birds released by the Indian Postal Department, and collect information about their place of origin and reasons for their migration to different localities in India and more. **Showcase** the postal stamps in your science laboratory/school library to popularise migratory birds.






## 12.7 How Does One Change Lead to Another?

Look at Fig. 12.13. It shows how one small change can lead to many others. For example, many plants in a pond start dying because of pollution. With fewer plants less oxygen will be

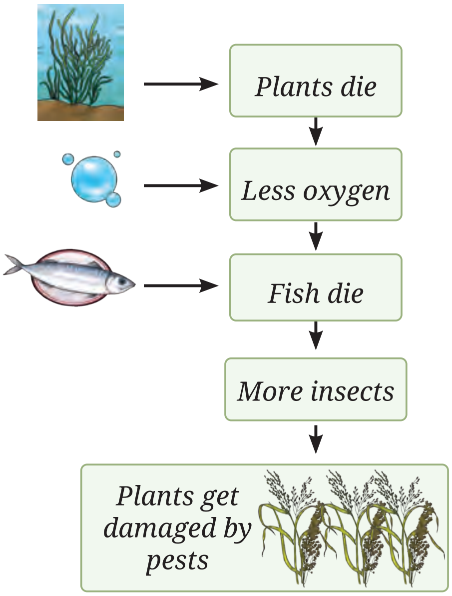



Fig. 12.13: One change leads to another

Fig. 12.14: Indian bullfrog

produced in water which will lead to a drop in the fish population in that water body. Reduction in fish population will have cascading effects and there will be less number of consumers in the pond. As a result, insects will increase in number. These insects will spread to nearby farmlands. This is how farmers will be compelled to use pesticides to grow their crops which may again adversely affect the environment. Further consequences may emerge in the form of other **environmental issues**.

What happens when we intervene in nature?

### Activity 12.9: Let us read

In the 1980s, India was a significant exporter of frog legs, especially of the Indian bullfrog (*Hoplobatrachus tigerinus*) (Fig. 12.14). This large-scale harvesting led to a decline in frog populations. Since frogs eat insects, their reduced numbers resulted in a rise in agricultural pests. This forced farmers to use more synthetic pesticides, which harmed the environment, soil and water quality, and affected the overall environmental and human health. The Government of India banned the export of frog legs to prevent further **ecological damage**.

An ecosystem stays in balance when interactions among organisms and their environment keep populations and resources stable. This balance is dynamic, not fixed, and can be disrupted by natural or human-made changes.

## 12.8 How Do Interactions Maintain Balance in Ecosystems?

Fig. 12.15: Competition among a community in an ecosystem

Besides feeding relationships, organisms also compete for common resources like food, water, physical space, or sunlight.

This competition helps control population size and keeps the ecosystem balanced. Without it, one species could multiply too much causing an imbalance in the ecosystem (Fig. 12.15).

There are other types of relationships too. Based on the example given in Fig. 12.16, what do you observe?

- **Mutualism:** Both organisms benefit. For example: Honeybees and flowers.
- **Commensalism:** One organism benefits while the other is not affected. For example: Orchids on trees.
- **Parasitism:** One organism benefits while the other is harmed. For example: Ticks on the body of dogs.

These interactions are all part of the complex web of life in an ecosystem.

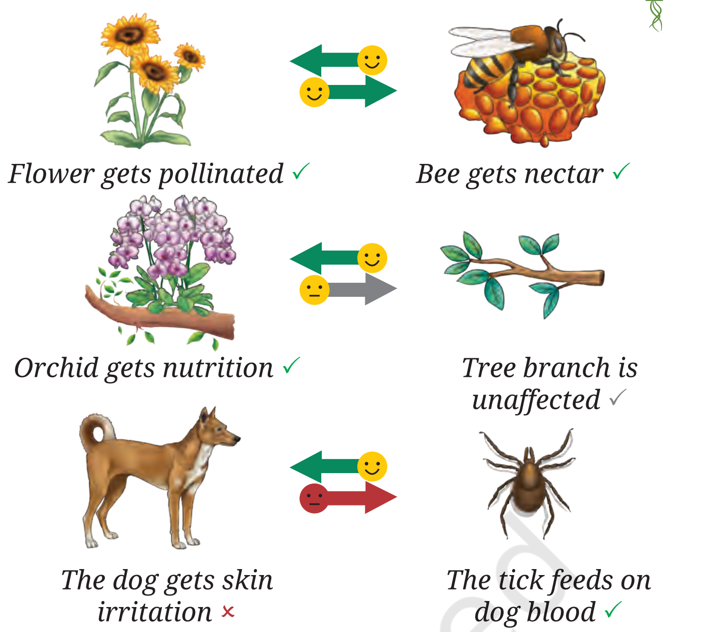



*Fig. 12.16: Different types of interactions between organisms*

## Be a scientist

Asir Jawahar Thomas Johnsingh (A.J.T. Johnsingh) was a famous Indian wildlife biologist who helped us understand forest ecosystems through the eyes of animals. He was a pioneer in studying wildlife through modern tracking system. His research showed how predators like tigers and leopards rely on prey, such as deer and wild boar, while he was working in Bandipur National Park, Karnataka. He proved that a healthy prey population is key to predator survival. He inspired many youngsters to study wildlife and protect the forests and biodiversity of India.

## 12.9 What Are the Benefits of an Ecosystem?

We have learnt that biotic components and abiotic components of an ecosystem depend on each other and support various life processes. Humans also benefit from ecosystems. For example, forests provide fresh air, fertile soil, food, fibres, timber, and medicines. Similarly, aquatic ecosystems provide water and food. Ecosystems also offer aesthetic and recreational value. This benefits and supports our well-being and shows how closely nature and humans are connected. However, when we overuse or misuse natural resources, we disturb the balance in nature.

Now let us look at a real-life example of a threatened ecosystem — the Sundarbans.

*Fig. 12.17: Mangrove forest in Sundarbans*

The Sundarbans have the largest mangrove forests in the world. Located where the Ganges and Brahmaputra Rivers meet between India and Bangladesh, the Sundarbans' forests and rivers are home to various flora and fauna, many of which are endangered. The Sundarbans protect us by slowing down strong winds and waves during storms and floods. The trees also absorb carbon dioxide from the air and release oxygen. Because of its importance, The United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the Sundarbans a World Heritage Site in 1987. However, the Sundarbans (Fig. 12.17) are under a serious threat. Mangrove trees are being cut for fuelwood and farming. Illegal hunting and overuse of forest resources are a threat to the wildlife living there. Pollution from industrial waste and untreated sewage in rivers are also damaging the water and habitat. These human activities disrupt the natural way ecosystems work.

Similarly, other ecosystems across India are also under threat. Problems like deforestation, overuse of natural resources, the spread of invasive species, unsustainable land use, and pollution are damaging forests, rivers, scrublands, wetlands, grasslands, and coastal areas.

How can we stop damaging forests, rivers, and wetlands? Think about what actions you and your community can take to protect these important places.

## Our scientific heritage

Protected areas are parts of land or water set aside to conserve wildlife and their habitats. India has many protected areas like national parks, wildlife sanctuaries, biosphere reserves, and community conserved areas. These places help protect entire habitats including endangered animals, birds, and many rare plants. Famous examples include Jim Corbett National Park (Uttarakhand), Manas National Park (Assam), Nilgiri Biosphere Reserve (Western Ghats), Chilika Lake (Odisha), Eaglenest Wildlife Sanctuary (Arunachal Pradesh), Hemis National Park (Leh), Keibul Lamjao National Park (Manipur), Pirotan Island Marine National Park (Gujarat). Protected areas play a big role in saving nature for future generations.

### 12.9.1 Human-made ecosystems

Humans have created artificial ecosystems like fish ponds, farms, and parks to meet their needs. When well designed, these can help reduce pollution, support biodiversity, and provide recreational spaces for people. Unlike natural ecosystems, these need human care and management. Can you name any human made ecosystem in your area?

### 12.9.2 How do healthy ecosystems serve our farms?

Farming, a major livelihood in India, can become unsustainable if not managed well by applying environment friendly farming practices.

Humans have been practising farming for thousands of years to grow food. As the population grew, our dependence on agriculture increased. Between 1950 and 1965, India faced a food crisis due to low crop production. In the mid-20th century, the use of tractors, machines, synthetic fertilisers, and pesticides helped increase food production. This period is known as the **Green Revolution**. However, these farming methods are now considered unsustainable because of the overuse of synthetic chemicals, excessive groundwater extraction, and growing only one type of crop for commercial gain. How do these practices harm both the environment and human health?

Many scientists believe that overusing pesticides and growing the same type of crop repeatedly on the same land leads to soil degradation. Understanding ecosystems can help us adopt better and more sustainable farming practices.

## Activity 12.10: Let us survey

Visit a nearby farm with your parents or teacher/interact with farmers in your community to find out about the farming practices they adopt.

- **Prepare** a list of questions for farmers to find out the pesticides and other farm inputs they use, and whether they reuse or recycle materials to improve their crops. Here are some sample questions:
  - How have your farming practices changed over time? And why?
  - What effects do you notice when using synthetic fertilisers and pesticides?
  - Have you seen any changes in soil health after using these synthetic fertilisers and pesticides?
- **Interact** with farmers based on these questions. Based on your findings, prepare a report.

*Fig. 12.18: Natural control of pests by predators—Beetle feeding on pests*

What inference do you draw from your interactions with farmers?

Synthetic fertilisers and pesticides have played a vital role in improving crop production and helped countries like India become food secure. However, their long-term use can affect the environment and soil health. Overuse of synthetic fertilisers may reduce soil fertility by decreasing friendly microorganisms in soil and lowering organic matter (humus), which helps bind soil particles. Without enough humus, soil becomes prone to erosion. Also, it reduces the population of natural predators which ultimately increase the population of pests (Fig. 12.18). Heavy irrigation and repeated ploughing can also disturb soil organisms like earthworms and snails, which are important for maintaining ecological balance.

Some pests may develop resistance to pesticides, making them difficult to control. Growing the same crop repeatedly, known as **monoculture**, can reduce crop diversity and affect pollinators, which are crucial for food production.

To make farming more sustainable, some farmers are exploring organic and natural farming methods. These aim to reduce the use of synthetic fertilisers and support sustainable farming, with minimal interference in natural ecosystems. Based on your learning, what practices do you think can help farmers protect the soil, the environment, and our food security for the future?

## Our scientific heritage

The ancient text *Vrikshayurveda* emphasises on soil health and nourishment. The text strongly advocates for the continuous nourishment of the soil through organic manure like *Kunapa Jala* (a liquid fertiliser made from animal and plant waste by the process of fermentation; that breaks complex substances into simpler ones) and other composted materials.

## Snapshots

- A habitat is a place that provides the right conditions for an organism to live and grow.

- Habitats have biotic components (plants, animals, microbes) and abiotic components (air, water, soil, temperature).
- The interaction between biotic components and abiotic components in an area forms an ecosystem.
- Ecosystems can be terrestrial (forests, grasslands, deserts) or aquatic (ponds, lakes, sea, oceans).
- Organisms often classified as producers (plants), consumers (herbivores, carnivores, omnivores), and decomposers (bacteria, fungi).
- Producers make their own food, while consumers eat plants or animals. Decomposers break down dead matter and recycle nutrients.
- Food chains depict who eats whom in an ecosystem, and food webs show how these chains are interconnected. The positions that different organisms occupy in a food chain are called trophic levels.
- Some organisms live in relationships, like mutualism (both benefit), commensalism (one benefits, other is unaffected), and parasitism (one benefits, one is harmed).
- The benefits that ecosystems offer are crucial for human survival and well-being. They provide clean air, water, food, medicine, and climate regulation.
- Human activities like pollution, deforestation, habitat loss, climate change, invasive species, and overexploitation of natural resources threaten ecosystems. Protecting them through efforts, such as conservation like national parks and sanctuaries is vital.

## Keep the curiosity alive

1. Refer to the given diagram (Fig. 12.19) and select the wrong statement.
   (i) A community is larger than a population.
   (ii) A community is smaller than an ecosystem.
   (iii) An ecosystem is part of a community.
2. A population is part of a community. If all decomposers suddenly disappear from a forest ecosystem, what changes do you think would occur? Explain why decomposers are essential.
3. Selvam from Cuddalore district, Tamil Nadu, shared that his village was less affected by the 2004 Tsunami compared to nearby villages due to the presence of mangrove forests. This surprised Sarita, Shabnam, and Shijo. They wondered if mangroves were protecting the village. Can you help them understand this?

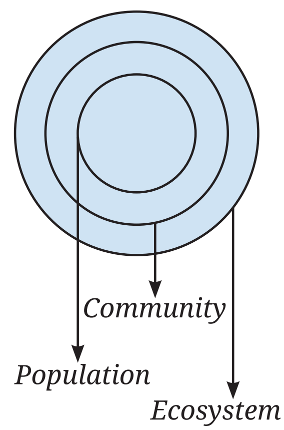


*Fig. 12.19: Population, community, and ecosystem*

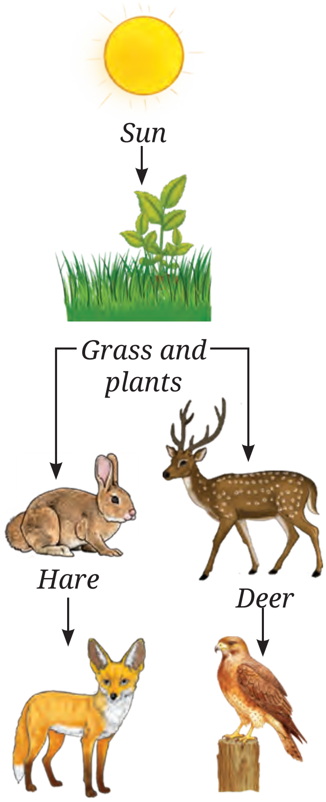


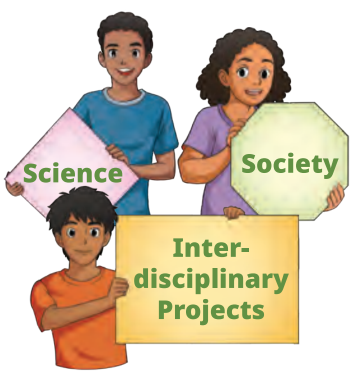

*Fig. 12.20: Parts of a food web*

4. Look at this food chain:

   Grass ⟶ Grasshopper ⟶ Frog ⟶ Snake

   If frogs disappear from this ecosystem, what will happen to the population of grasshoppers and snakes? Why?
5. In a school garden, students noticed fewer butterflies the previous season. What could be the possible reasons? What steps can students take to have more butterflies on campus?
6. Why is it not possible to have an ecosystem with only producers and no consumers or decomposers?
7. Observe two different places near your home or school (e.g., a park and a roadside). List the living and non-living components you see. How are the two ecosystems different?
8. 'Human-made ecosystems like agricultural fields are necessary, but they must be made sustainable.' Comment on the statement
9. If the Indian hare population (Fig. 12.20) drops because of a disease, how would it affect the number of other organisms?

## Discover, design, and debate




- Plan a clean-up day at school or a nearby park. Wearing gloves and using bags, collect the litter you find. Discuss the kinds of waste you found. Which was the most common? How can we reduce such waste?
- In Arunachal Pradesh, the Nyishi and Mishmi tribes treat the Tiger as sacred. In Chhattisgarh, the Baiga tribe worships Bagheshwar or Bagesur Dev and believes the Tiger is the protector of the forest. Find out about another Indian tribe that has a special bond with any animal.
- Pick a tree near your home or school. Observe it once a week for 4 weeks. Note any new leaves, flowers, fruits, or visiting birds and insects. Record your observations. You may even upload your findings to www.seasonwatch.in and become a young citizen scientist.




**Prepare some questions based on your learnings so far ...**

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- Interact with farmers and record indigenous practices followed by them for sustainable farming. Create a sustainable herbal garden/natural farm at home or at school. It could be a group activity with students from different grades.

*Fig. 12.21: Farming Practices*

- Look at Fig. 12.21 to understand the different farming practices adopted by farmers or you may also visit a nearby farm with an elderly person to observe the same. List a few suggestions in your notebook to improve farming practices by adopting eco-friendly and sustainable techniques. You can also make posters or model and display while participating in school functions, science fairs or Krishi Mela. The school may also invite agricultural scientists, farmers, and experts to discuss the prevalent farming practices with the students.



**Reflect on the questions framed by your friends and try to answer ...**

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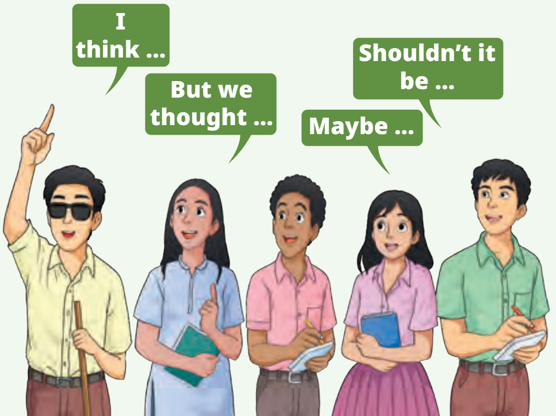

# Our Home: Earth, a Unique Life Sustaining Planet

# 13

## Probe and ponder

- What do you think Earth would look like if there were no life on it at all?
- Life on Earth has survived for billions of years. What allows it to keep going despite major changes and disasters?
- Why don't dogs lay eggs? Or hens give birth to live chicks?
- If a spaceship carried soil and water to Mars, could plants start growing there?

Share your questions

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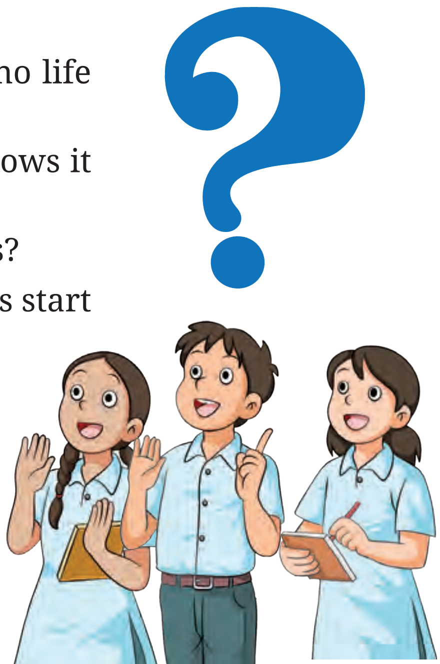


We have now reached the final chapter of this book, the concluding chapter in our scientific journey through the middle stage. It is time to put together all that we have seen and learnt and try to understand why our home, planet Earth, is like no other place in the known universe. As you have learnt in *Curiosity*, Grades 6 and 7, the Earth is a planet orbiting the Sun. However, it is not just any planet. It is a planet that sustains life—full of diverse landscapes, from towering mountains and vast oceans to endless deserts and lush forests. Today, our satellites allow us to take amazing pictures of our planet. The image in the beginning page was taken by an Indian Space Research Organisation (ISRO) Earth Observation Satellite and made by combining nearly 3000 smaller images, like pieces of a mosaic. Although it looks beautiful, it's a false colour image, where scientists use different colours to show different types of information. These satellite images help us study plants on land and tiny organisms in the ocean, and can even detect things like ocean temperature, oil spills, and wind direction. In this chapter, we will uncover the unique conditions that make Earth the perfect home for living beings.

## 13.1 Why Is Earth a Unique Planet?

What makes the Earth so special? While there are perhaps billions of planets in the universe, Earth is the only one where life, as we know today, exists and thrives in all its forms.

Have you ever wondered where all life on Earth actually exists? All the mountains, rivers, forests, animals, and people are found on just a very thin layer on the surface of our planet. From the tallest mountain to the deepest ocean trench, the crust, where all of life exists, is tiny compared to the size of Earth. If Earth were the size of an apple, the crust would be as thin as the apple's skin as shown in Fig. 13.1. This delicate, life supporting layer is what makes Earth truly special.

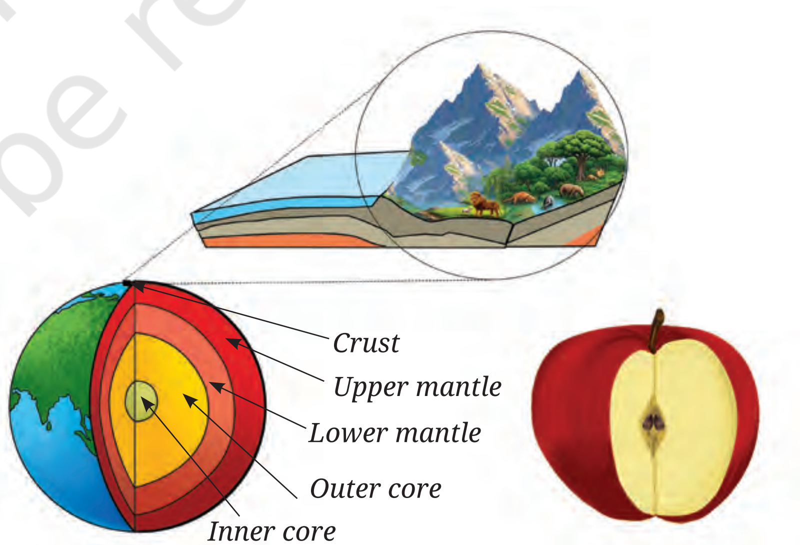



*Fig. 13.1: The Earth's crust is like the thin skin of an apple*


Let us **conduct** an activity to list out some features of the Earth that you think make it special.

### Activity 13.1: Let us find out

- List some features of the Earth that we often take for granted, but are interesting and important to us. Write them in Table 13.1. We have filled in a few for you.

**Table 13.1: Interesting features about the Earth**

| S.No. | Interesting features of the Earth |
|---|---|
| 1. | The air we breathe doesn't fly off and disappear into space. (We learnt in Chapter 7 that the particles of a gas move freely, and gases do not have a fixed volume) |
| 2. | We can stand on the ground held by gravity (as we learnt in Chapter 5), but our heart can pump blood up to our head. |
| 3. | |
| 4. | |



Discuss the features you have listed with your teacher and friends. You may realise that the Earth is interesting and important to us in many ways. It provides us with the air that we breathe, the water that we drink, and the soil that helps in growing crops. The Earth also provides us materials like rock and timber with which we build our homes, buildings, and roads. You must be curious to know what makes the Earth a unique planet which not only allows life like us to exist but also sustains it.

## 13.2 What Do the Planets of Our Solar System Look Like?

In *Curiosity*, Grade 6, you had studied the solar system in the chapter 'Beyond Earth'. Let us recall some of the things we had learnt. Our solar system has eight planets that go around the Sun in nearly circular orbits. In order of their increasing distance from the Sun, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Out of all these planets, Mercury, Venus, Earth, and Mars, are relatively small and rocky planets, while Jupiter, Saturn, Uranus, and Neptune are large planets, mostly made of gases.

Let us find out more about the planets in the solar system by **performing** Activity 13.2.

## Activity 13.2: Let us find out

- **Collect** information about the temperature and size of the planets in the solar system, and check if they have an atmosphere.
- You may collect this information from books in your school library, trusted websites, or discuss with your teachers.
- Fill out the missing information in Table 13.2.

**Table 13.2: Planets in our solar system**

| S.No. | Planet | Average temperature (°C) | Radius, compared to the Earth | Has an atmosphere? |
|---|---|---|---|---|
| 1. | Mercury | 170 | | No |
| 2. | Venus | 450 | 0.95 | Yes |
| 3. | Earth | 15 | 1 | Yes |
| 4. | | | | |
| 5. | | | 11 | |
| 6. | | | | |
| 7. | | | | |
| 8. | | –200 | 4 | |



We know that all planets in the solar system get their energy from the Sun. Thus, when a planet is close to the Sun, it would be very hot. As we move away from the Sun, planets should get colder. Is this what you found in Table 13.2? This is generally correct, except that Venus, the second planet from the Sun has the highest average temperature and is the hottest planet. Why is this so?

Venus is the hottest planet not because it is the closest to the Sun, but because its thick atmosphere traps heat.

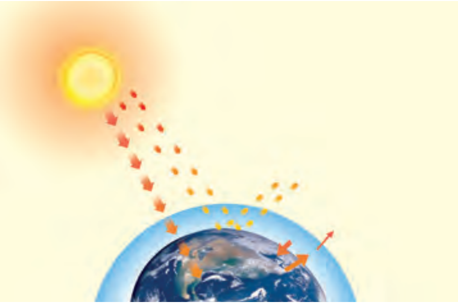


*Fig. 13.2: Schematic of greenhouse effect on Earth*

The air on Venus is almost entirely made up of carbon dioxide gas, which does not let the heat escape. This is called the **greenhouse effect** (Fig. 13.2), and it makes Venus even hotter than Mercury, which is relatively closer to the Sun. On the Earth also, gases like carbon dioxide in the atmosphere trap heat by absorbing the radiation given off by the Earth, after it gets warmed by the Sun. Thus, greenhouse effect plays an important role in maintaining just the right temperature on Earth.

**A step further**

The greenhouse effect that causes a planet like Venus and Earth to trap heat does not work the same way as a greenhouse for growing plants in a cool climate. On Venus or Earth, gases like carbon dioxide in the atmosphere trap heat by absorbing the radiation given off by the Earth, after it gets warmed by the Sun. A plant greenhouse, on the other hand, traps warmed air simply because it is a closed space, usually with glass walls (Fig. 13.3). It heats up during the day, but the air stays in and the heat does not escape easily. So while both keep things warm, they do it differently!

*Fig. 13.3: Greenhouse for plants*

## 13.3 What Makes the Earth Suitable for Life to Exist ?

### 13.3.1 Position of the Earth

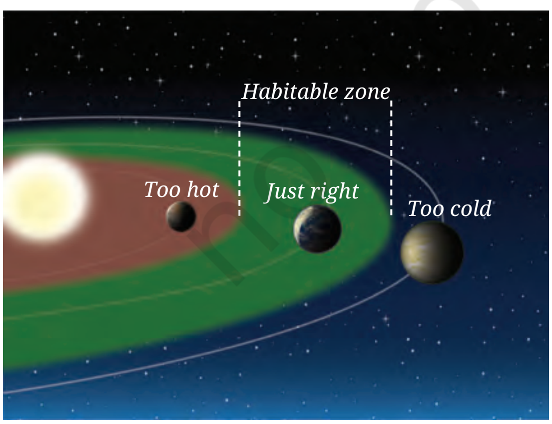



*Fig. 13.4: The habitable zone around a star*

The most important reason why the Earth can support life is its distance from the Sun. It is just at the right distance, where the temperature allows water to exist in a liquid form. If the Earth were closer to the Sun, it would be too hot and all the water would evaporate; if it were farther away, it would be too cold, and all the water would freeze. In such extreme conditions, it would have been impossible for most life forms—especially plants, animals, and humans—to grow and thrive on Earth. Although some microbes, like certain bacteria, can survive in frozen environments, from what we know so far, liquid water is essential for life to evolve. Earth's distance from the Sun allows water to remain mostly in liquid form, which is essential for the development and sustenance of life in all its form. The range of distances from the Sun (or another star) over which water remains liquid is called the **habitable zone**, or sometimes also called the '**Goldilocks zone**' (Fig. 13.4).

*Fig. 13.5: Earth — The blue planet*

As you have also studied in Social Science, most of Earth's surface is covered with water. Thus, when seen from space, the Earth looks blue because of the vast amount of water—hence the name Blue Planet (Fig. 13.5).

## A step further

Did Mars ever support life?

Mars lies at the edge of the Sun's habitable zone. Several spacecrafts have been sent to Mars, rovers have landed and explored its surface, but no proof of life has been found yet. However, scientists think that in the past, Mars may have had liquid water—maybe even some lakes—and conditions that could support simple life forms (Fig. 13.6).

This is one reason Mars continues to interest scientists. It also reminds us that science doesn't always have final answers. As we explore more, we may find new clues—or even new kinds of life. Science stays open to change when we learn more.

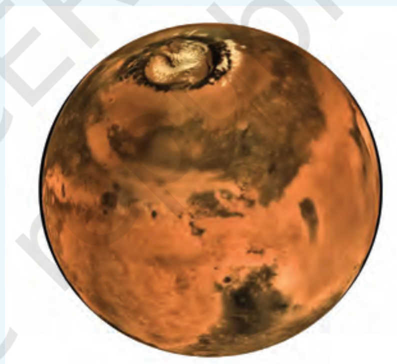


*Fig. 13.6: Mars*



### 13.3.2 Size of the Earth

There are some other important factors that make the Earth habitable. In our solar system, the orbits of most planets, including the Earth are almost circular. This keeps the amount of sunlight and heat nearly steady throughout the year, preventing extreme summers and winters at most places.

However, moderate temperature due to the right distance from the Sun isn't the only factor that makes the Earth habitable. The planet is also the right size to support an atmosphere. As you learnt earlier, the atmosphere is the layer of gases that surrounds the Earth, and it plays a major role in sustaining life. You also learnt in Chapter 5 that the Earth's gravity pulls objects towards it. If Earth were much smaller (but with the same average density), its gravity would have been too weak to hold on to the gases in our atmosphere, and they would have escaped into space. On Mars, the atmosphere is 100 times thinner than on Earth, and Mercury has no atmosphere at all.

On the other hand, if the planet was too large, and gravity was much stronger, it would perhaps pull us down to the planet with such a large force that our bones could get crushed! Due to the right size of the Earth, it is able to support atmosphere which is essential for life.

The presence of oxygen in the Earth's atmosphere allows us to breathe, and is needed by almost all forms of life on Earth. But oxygen has another important role. Some of the oxygen in our atmosphere, gets converted to another form called ozone (a three-atom oxygen molecule), and forms an important part of the atmosphere called the **ozone layer**. This layer acts like a shield, blocking harmful ultraviolet (UV) rays from the Sun that can damage living cells.



## Our scientific heritage

India's Mangalyaan (Mars Orbiter Mission), launched in 2013 by Indian Space Research Organisation (ISRO), was a big step in exploring Mars (Fig. 13.7). It carried tools to study the planet's atmosphere, surface, and signs of past water. Some of these sensors help scientists ask big questions—like was Mars ever suitable for life? Mangalyaan showed the world that India could do space science with smart, low-cost technology—and it helped bring Mars closer to all of us.

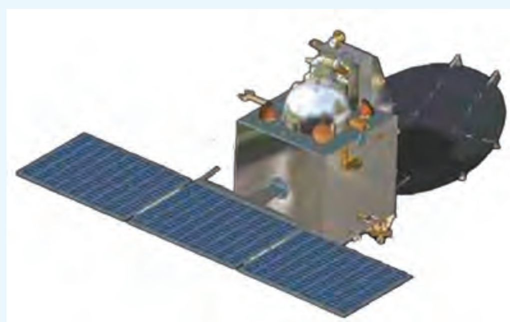


*Fig. 13.7: Mangalyaan*

### 13.3.3 Magnetic field of the Earth


In *Curiosity*, Grade 6, we learnt that a freely suspended magnet always settles in a fixed direction. This is because the Earth itself behaves like a giant magnet. You have also seen in Chapter 4 that the region around a magnet where its effect is felt has a magnetic field. It is believed that the movement of molten iron in Earth's core may be the origin for Earth's magnetic field.

Earth is constantly hit by tiny, high-energy particles that come from space. Some come from far across the universe and are called **cosmic rays**. Other particles come from the Sun and are called the **solar wind**. These particles can be harmful as they can damage the atmosphere, reduce the ozone layer, and let in more harmful UV rays, which can affect life on Earth.

Thankfully, the Earth's magnetic field acts like a protective shield. It pushes many of these harmful particles away from the Earth, keeping our atmosphere, and hence life on our planet safe.

Earth's unique position in the solar system—allows the presence of liquid water—along with its size, atmosphere, and magnetic field, all help make it a planet where life can emerge and thrive.


## 13.4 What Allows Life to Be Sustained on Earth?

Earth has the right conditions for life, but it is the beautiful connections between living and non-living things that help life to thrive. In *Curiosity*, Grades 6 and 7, you learnt about key natural resources, such as, air, water, sunlight, soil, and minerals. You also learnt about the important life processes in plants and animals. Now, let us **explore** how all these elements interact to support and sustain life on Earth.

### 13.4.1 Air, water, and sunlight

We know that the atmosphere contains oxygen, which humans, animals, and plants use for respiration. In the presence of sunlight, plants take carbon dioxide from the air and water from the soil to prepare food by photosynthesis. In the process, oxygen is released, which is needed for respiration.

We have learnt, radiation from the Sun heats the Earth. Some of this heat is trapped by the atmosphere due to the greenhouse effect. This effect though mild, keeps the temperature just high enough for water to remain in the liquid state. In *Curiosity*, Grade 7, you also learnt about heat transfer by radiation. Without an atmosphere, the Earth would lose heat to space and become too cold. So the greenhouse effect helps keep the Earth warm.

Water is essential for life. You have learnt that it covers about 70 per cent of the Earth's surface and is found in ponds, lakes, rivers, springs, seas, oceans, and groundwater. All this water forms the **hydrosphere**. In Chapter 7, you learnt that water is a good solvent. In *Curiosity,* Grade 7, we learnt how water transports nutrients from soil to leaves in plants. In animals, it regulates body temperature, aids digestion, and ensures hydration, all essential for health and life.

*Fig. 13.8: Life in water*

Though much of Earth is covered by water, we still know little about what lives deep in the oceans. The hydrosphere is home to millions of life forms, from tiny planktons to giant whales, many still being discovered. Oceans, lakes, and rivers provide rich environments for aquatic life (Fig. 13.8). Freshwater is also needed to grow crops and support people around the world.

Water vapour in the air forms clouds and brings rain or snow. This refills rivers, lakes, and underground water. Rainfall affects the kinds of plants and animals that can live in a place. Moving air also shapes weather and rainfall—which influence farming, water supply, and life on land.

### 13.4.2 Soil, rocks, and minerals

Beneath our feet lies something remarkable—the Earth's crust, made of rocks, soil, and minerals. It may seem hard and lifeless, but it provides almost everything life needs to grow and survive. From soil that helps plants grow to minerals that give us salt, coal, oil, and metals like iron and copper—this outer layer support both ecosystems and human life. The solid parts of the Earth, including materials like rocks, soils, and minerals are known as the **geosphere**.

Soil may look like simple dirt, but it is rich in nutrients like nitrogen and potassium that plants need to grow. These nutrients come from the slow breakdown of rocks and the remains of plants and animals.

There are various types of landforms, rocks, soils, etc., on Earth. This variety along with the processes that shape and alter them is called **geodiversity** (Fig. 13.9). It helps create unique habitats where different types of life can thrive. The non-living parts of nature, like soil, rocks, and water, aren't just a background—they help shape the story of life itself.

*Fig. 13.9: Geodiversity*

### 13.4.3 Plants, animals, and microorganisms

From the chapter on microbes to the chapter on ecology, we have seen that the Earth is full of life—from trees, shrubs, herbs, to animals, insects, and tiny organisms invisible to the naked eye. All living beings, along with the places where they live, make up the **biosphere**. This includes land, water, and air, where life interacts with its surroundings to survive and grow.

As you learnt in Chapter 12, living beings depend on one another and their environment. Plants make food through photosynthesis, animals eat plants or other animals, and decomposers break down dead matter and return nutrients to the soil. Nature works together as a system to support life.

### 13.4.4 The importance of balance

Have you ever wondered how so many things on Earth stay in balance? Earth is like a giant teamwork project between nature, weather, and life itself. It is a vast, living system where land, air, water, and living things support and affect one another. Even a small change in one part—like cutting down a forest—can impact rainfall, soil, air quality, and the animals that live there. Life on Earth survives not because of just one thing, but because everything works together in balance. It is this balance that keeps our planet habitable. That's why preserving and protecting clean air, water, soil, and all forms of life isn't just important but essential for keeping Earth healthy for the future.

## 13.5 What Keeps Life from Disappearing?

If plants and animals didn't reproduce, life would eventually disappear from Earth. Reproduction ensures that each type of organism continues to exist, maintaining the continuity of life.

We usually expect that animals will produce young ones that resemble them—cows have calves, and cats have kittens. This happens because parents pass on instructions to their offspring about how to develop from a single cell. These instructions, called **genetic material** or **genes**, are stored inside every cell of a living being. You can think of genes as a detailed instruction manual inside each cell. Some instructions tell the cell how to make blood, while others guide the formation of bones, muscles, or skin. Together, these instructions ensure that a calf grows into a cow, or a kitten grows into a cat.

But reproduction does more than just create more of the same kind of living beings. It also allows for small changes in the instructions that are passed down from parents to offpsrings. Sometimes, these changes help a plant or animal survive better in a new environment. For example, over time, camels developed humps to store fat and survive in deserts. Even microbes evolve—some bacteria, as you learnt in the chapter on health, have become resistant to antibiotics, helping them persist. Over many generations, such changes can lead to new features—or even completely new types of living beings. So, reproduction not only keeps each kind continuing, but also helps life adapt change, and continue in new forms (Fig. 13.10).

But how can the same process lead both to similarity (an animal gives birth to similar individual, such as a cow gives birth to a cow) and variation (shows different characteristics like difference in color and height of to individuals of some kind)? That is a fascinating puzzle. There are two types of reproductive processes—one in which the young are almost exactly like their parent and another in which they look slightly different from their parents.

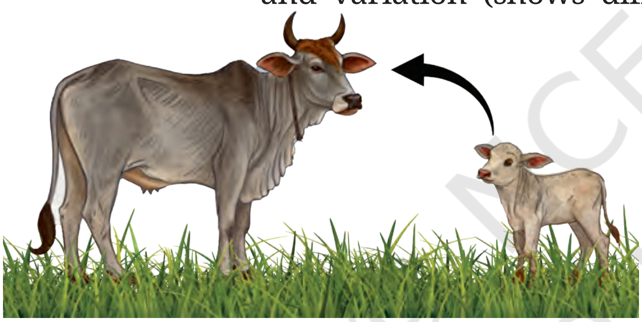


*Fig. 13.10: Development of calf to cow*

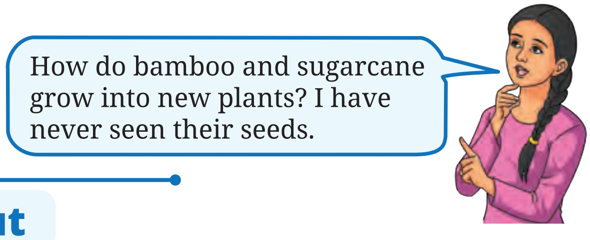
In asexual reproduction, a single parent produces new individuals that are exact copies of itself (exact in terms of the instructions inside the cell). In sexual reproduction, instructions from two parents combine to create offspring that are not exactly like either of the parent. They share some traits with both parents, but also have differences. This mixing helps keep useful features while allowing new ones to appear. Over many generations, these small differences can add up—leading to big differences, and even new life forms.

Let's explore how reproduction takes place in plants and animals, and how it helps living beings develop special features and sometimes change over time.

### 13.5.1 Asexual reproduction

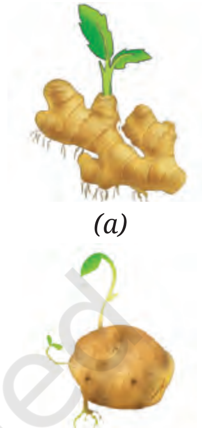
Many plants can reproduces when any part of the plants—leaf, stem, or root—is planted in soil. This kind of reproduction is called **vegetative propagation.**

Can you **observe** and list some plants around you that grow this way?




## Activity 13.3: Let us find out

- Take some parts of plants like stem cutting of a money plant, the 'eyes' of a sprouted potato, or a piece of ginger (Fig. 13.11b).
- Plant each of them separately in moist soil (not too deep). For money plant, you can just put a cutting in a glass container which makes it easy to observe.
- Make sure they get all the conditions they need to grow—like water, air, and sunlight.
- Watch them every day and note how many days it takes for roots stem and leaves to appear. Also observe when the first new leaf appears.



*(a)*

*(b)*

*Fig. 13.11: Vegetative propagation—(a) Ginger; (b) Potato*

### Ever heard of ...

Not just plants—microbes and simple animals also reproduce asexually. For example, single-celled organisms like bacteria and amoeba divide into two identical individuals. Some multicellular organisms like algae can regrow from small cut parts. Hydra, another simple animal, grows tiny buds on its body that breaks off and grow into new individuals.

Planaria (Fig. 13.12), a type of flatworm, can regrow from a fragment of its body! Scientists study this organism to understand regeneration in animals.

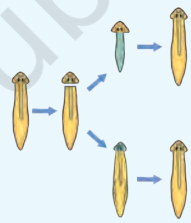


*Fig. 13.12: Planaria*

### 13.5.2 Sexual reproduction

In this type of reproduction, two parents are involved—usually called male and female. This is easy to observe in animals, but did you know even flowering plants have male and female parts? Some microorganisms like bacteria and yeast also have two 'mating types' that act like the two parents.

### Special cells for reproduction

You might wonder if both parents pass on their genetic material for making a new organism, won't the child end up with double the amount of instructions? And would not this keep doubling every generation?

This does not happen because each parent makes specialised reproductive cells, called **gametes**. These carry only half of the parent's genetic material . When male and female gametes join, they form a new cell with a complete set of instructions—half from each parent.

Babies do not look exactly like their mother or father. Even brothers and sisters in the same family can look different from each other. This is because every baby gets a mix of genetic information from both parents through gametes. Each gamete carries a different set of instructions for things like eye colour, hair type, and more. These instructions mix in different ways when the sperm and eggs joins to form a baby. These instructions mix in different ways each time, so each child is unique. No wonder one child may 'inherit' a nose similar to mother and another may inherit eyes similar to father. It all depends on which pieces of the parent's 'instruction book set' came together.

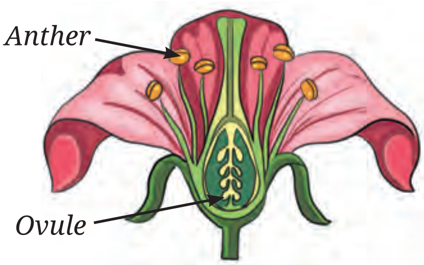


*Fig. 13.13: A flower*

## Sexual reproduction in plants

Plants use different parts of their flowers to produce male and female gametes. Pollen grains found inside the anther of a flower are the male gametes, while ovules, found deep inside the flower, are the female gametes. Pollen is carried to another flower by wind, insects, or animals—this process is called **pollination**. When the male and female gametes combine, it is called **fertilisation**, forming a zygote that becomes the seed. The fleshy part of the flower around the ovule develops into a fruit (Fig. 13.13).

When birds or animals eat the fruit, the seeds often get dropped far from the original plant—a helpful way for plants to spread. That's how a banyan seed, dropped by a bird that ate a fruit and excreted the seed, might sprout in a crack in a wall after the rains. When seeds get water, they use stored nutrients to grow roots and shoots. Remember in Grade 6 you had studied the germination of seeds where you observed tiny shoots and the first leaves appear.

## Sexual reproduction in animals

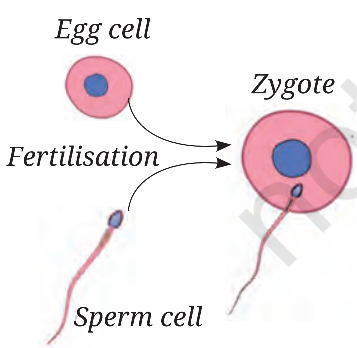


*Fig. 13.14: Formation of zygote*

In animals, gametes are called sperm (male) and eggs (female). Fertilisation may take place in water, for example, male and female fish or frogs eject sperm and eggs, respectively, into the water where they combine to form the zygote. In these animals, the development of the zygote into an embryo also takes place in water (Fig. 13.14).

In birds and mammals, including humans, sperm are deposited inside the female and fertilisation takes place when the sperm swim towards the egg produced by the female. After this step, birds and mammals follow different processes.

In birds, the fertilised egg (zygote) is 'laid' by the female. The development of the zygote into an embryo happens after the egg is laid during the hatching process. Think about how much 'food' the female parent has to put into each egg—it has to last for the developing embryo until it hatches. This is one strategy to ensures supply of nutrition to the embryo.

In most mammals, the development of the zygote into an embryo takes place inside the body of the female. The mother's body provides all the food and oxygen the baby needs to grow until it is born. This is a different way of giving nutrition to the developing baby, compared to animals like birds that lay eggs. What are the advantages and disadvantages of giving birth to young ones vs. laying eggs? Do you think animals like dogs, cows, or humans could lay eggs like birds? Why or why not?

## 13.6 What Are the Threats to Life on Earth?

We know that life on Earth depends on a delicate balance of living and non-living things working together. But human actions are disturbing this balance. Even small changes in global temperature, oxygen levels, or the ozone layer can put life at risk.

Today, the biggest environmental challenges that we face are climate change, biodiversity loss, and pollution—together known as the triple planetary crisis.

Burning fossil fuels like coal and oil releases greenhouse gases like carbon dioxide and methane. These trap even more heat in the atmosphere which causes global warming. Normally, Earth keeps a balance since trees, plants, and even tiny ocean planktons absorb carbon dioxide as they grow. But when we burn fossil fuels, we release extra carbon that has been locked underground for millions of years. The Earth cannot absorb this fast enough, so the heat builds up. Even a small increase in temperature can melt ice caps, raise sea levels which could flood many coastal cities, cause extreme weather conditions, and lead to many plants and animals disappearing. These long-term changes in temperature, rainfall, and weather patterns are called **climate change**.

When natural habitats are destroyed, plants and animals may disappear, upsetting ecosystems. For example, as we saw in Chapter 12, if grasses vanish, animals that feed on them like deer or grasshoppers struggle to survive. And without herbivores, predators like tigers or foxes lose their food too. Every type of living thing has a role, and losing even a few weakens nature's ability to support life.

Fig. 13.15: Air pollution

Pollution adds to the problem. Air pollution from factories, vehicles, and burning fuels harms both people and the nature. It can cause breathing problems, damage crops, and lead to smog and acid rain (Fig. 13.15).

Climate change affects everything—from crop growth and water supply to wildlife habitats and human health. To protect life on Earth, we need to cut pollution, use cleaner energy, and make wiser choices. We have also learnt that life on Earth flourishes within a delicate balance supported by interdependent natural systems. However, this balance is increasingly threatened by human actions. For example, a little less or more of oxygen in air, or a little lower or higher temperature of the Earth, or a little less of ozone in the atmosphere, could endanger life on the Earth.

**Ever heard of ...**

Countries around the world have made global agreements to protect the environment. The Montreal Protocol (1987) helped reduce harmful chemicals like Chlorofluorocarbons (CFCs), allowing the ozone layer to slowly recover. The Earth Summit (1992) led to international efforts on climate change and biodiversity. Later, the Kyoto Protocol (2005) and Paris Agreement (2015) committed countries to reduce greenhouse gas emissions. The Paris Agreement set a goal to limit global warming to below 1.5 °C, but as of 2025, the world is not on track to meet that goal. Much more action is needed to avoid any more adverse effects of climate change.



Water and soil pollution are serious threats to life (Fig. 13.16). Factory, farm and plastic waste harm aquatic life and make water unsafe. Excess fertilisers and poor waste disposal pollute soil, reduce crop yield, and spread harmful substances through the food chain. Protecting them requires better waste management and sustainable farming practices.

Fig. 13.16: Water pollution

We have seen above that all the Earth system, such as hydrosphere, biosphere, atmosphere and geosphere are connected—so damage to one can affect the others. Protecting the climate means cutting down on greenhouse gases by using renewable energy like solar and wind, improving energy use, and choosing environmentally friendly ways to travel. At the same time, preserving biodiversity is key as diverse ecosystems are stronger and more balanced. Local communities can play a big role in using natural resources sustainably.

Everyone can help. Reusing, repairing, and recycling items like clothes and plastic reduce pollution and waste. Small actions like saving energy and water add up. Learning more, sharing ideas, and encouraging others also makes a difference.

In **conclusion**, sustaining life on Earth needs action from all of us—from local communities to global leaders. By working together and living responsibly, we can protect this unique planet and its future.

## Snapshots

- Our Earth is a unique planet in the solar system as it supports life.
- Earth orbits the Sun at a distance where the temperature is neither too hot nor too cold, which allows water to exist in liquid form. This region is called the habitable zone or Goldilocks zone.
- Further, the Earth orbits the Sun in a nearly circular orbit ensuring that the Earth is not too hot or too cold during any part of the year.
- The Earth's gravity is just enough to not let atmosphere escape into space. It is also not too high where creatures would be crushed by their own weight.
- Presence of ozone in the atmosphere prevents harmful ultraviolet rays from reaching the surface of the Earth.
- The magnetic field of the Earth shields it from high-energy particles that would otherwise hit the Earth and destroy life.
- The atmosphere (consisting of air), hydrosphere (consisting of water), geosphere (consisting of the solid part of the Earth), and biosphere (consisting of life) interact and together sustain life on the Earth.
- Reproduction is essential to ensure the continuity of life on Earth.
- Reproduction can be either asexual or sexual.
- In asexual reproduction, a single parent produces new individuals that are exact copies of itself.
- Sexual reproduction make it possible for new features to appear in the following generation.
- In different animals, the development of the zygote into an embryo takes place either inside or outside the body.
- Climate change, biodiversity loss, and pollution are threatening life on Earth. Together, these challenges are known as the triple planetary crisis.

## Keep the curiosity alive

1. What is one major reason Mars cannot currently support life like Earth?
   (i) It has too many volcanoes.
   (ii) It is too close to the Sun.
   (iii) It lacks a thick atmosphere and liquid water.
   (iv) Its magnetic field is too strong.
2. Which of these is an example of geodiversity?
   (i) Variety of bird chirping in a forest.
   (ii) Different landforms like mountains, valleys, and deserts.
   (iii) Changing weather during monsoons.
   (iv) Number of different types of fish in a pond.
3. If the Earth were smaller with the same density, what might happen to its atmosphere?
   (i) It would become thicker and hotter.
   (ii) It would escape into space due to weaker gravity.
   (iii) It would become frozen.
   (iv) It would cause stronger winds.
4. In sexual reproduction, why are offspring different from their parents?
   (i) They grow in different climates.
   (ii) They eat different food.
   (iii) They acquire new instructions after birth.
   (iv) They get mixed instructions (genes) from both parents.
5. You notice tiny green plants growing in cracks on your school wall after the monsoon. Where do you think the seeds came from? What conditions helped these plants grow there?
6. A city has recently cut down a large patch of forest to build new roads and buildings. Discuss the possible effects this could have on the local climate and biodiversity? How might this affect water availability or quality in the area?
7. A friend says, “The Earth has always had climate changes in the past, so today’s global warming is nothing new.” How would you respond using what you’ve learnt in this and other chapters of your science book?




**Prepare some questions based on your learnings so far ...**

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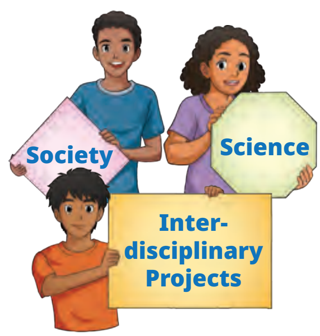
8. Imagine Earth's magnetic field suddenly disappeared. What kinds of problems could arise for life on Earth? Explain.
9. You are tasked with designing a new settlement for humans on Mars. Name three things you would need to recreate from Earth to support human life there. Which of these do you think is the hardest to replicate, and why?
10. In a village, the temperature has been increasing and rainfall has become unpredictable over the past few years. What could be causing this change? Suggest two ways the village could adapt to these new conditions.
11. If there were no atmosphere on the Earth, would it affect life, temperature, and water on the planet? Explain.
12. Discuss five examples of vegetative propagation.

## Discover, design, and debate

- Design an 'Earth Survival Kit'. Imagine you're building a tiny model of Earth for another planet. What must it have to support life, and why?
- India is planning for a challenging lunar mission, Chandrayaan-4, which will bring back samples of soil from the Moon. If the Moon had water, could plants grow in that soil? Think of some experiment that could help you explore whether plant growth is possible on the Moon.
- Flowers are often brightly coloured and have a pleasant smell. How do you think these features help the plant reproduce?
- Why do animals like fish and frogs lay hundreds or even thousands of eggs at a time, while other animals lay only a few? What might be the advantages and disadvantages of laying so many eggs?
- Birds like sparrows build nests and care for their eggs and chicks, while reptiles like snakes usually lay their eggs and leave them without protection. How might this difference in parental care affect the chances of survival for the young ones in each case?






**Reflect on the questions framed by your friends and try to answer ...**

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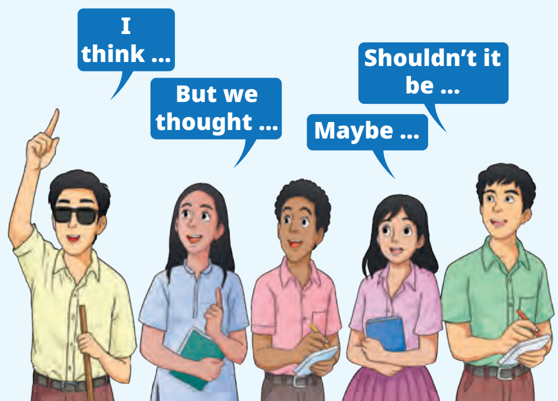

# It's never the end, my friend!

And we have arrived at the final page of our Grade 8 science journey. But remember, this is not the end of your exploration. Throughtout the year, we hope you have learnt to ask deeper questions, design investigations, and think like real scientists do. Whether you wondered about how forces work, explored the remarkable balance of our planet, or investigated how ecosystems are connected, you've already entered the Investigative World of Science.

If you noticed, we left space in every chapter for you to ask your own questions. What are the things around you that puzzled you? Perhaps you noticed how water droplets on a leaf act like a lens, or wondered why different birds have different flight patterns. Things that you notice, and the questions you ask about them are the very beginning of scientific investigation. This textbook has been designed to guide you — rooted in real observations, yet lifting your imagination to fly as high as a kite. But the real adventure belongs to you: keep asking, keep experimenting, keep sharing your findings with your friends and teachers.

As you close this book, remember that next year, you will enter the secondary stage, where we will go deeper into the world of science. The story will continue with more detailed investigations, bigger challenges, and greater discoveries. So never stop wondering, never stop experimenting, and never stop believing that your curiosity can change the world. We'll meet you again on those pages — because in science, it is never the end, my friend!