

Science and Technology — Grade 10 (SEE)

Comprehensive Teacher-Style Study Notes

Source Textbook: *Science and Technology, Grade 10* — Curriculum Development Centre (CDC), Sanothimi, Bhaktapur **Publisher:** Government of Nepal, Ministry of Education, Science and Technology **Edition:** 2080 BS (2023) **Aligned with:** National Curriculum Framework, 2076 · Secondary Level Curriculum (Grade 9–10), 2078 **Compiled for:** SEE (Secondary Education Examination) preparation — chapter-wise, topic-wise, in-depth

A Note About This Document

The original PDF body content of the textbook is image-based (scanned pages) and could not be extracted as text in this environment because OCR tools were not available. The **chapter list and page numbers** were extracted directly from the textbook's table of contents. The detailed notes here are written from the **standardised CDC Grade 10 Science and Technology curriculum** — the same content as in the textbook.

If any detail differs from your specific textbook copy, always follow your textbook. If you spot any error, please let me know so it can be corrected.

Chapter Index

#	Chapter	Page
1	Scientific Learning	1
2	Classification of Living Beings	15
3	Honey Bee	59
4	Heredity	73
5	Physiological Structure and Life Process	116
6	Nature and Environment	142
7	Motion and Force	167
8	Pressure	197
9	Heat	224
10	Wave	242

11	Electricity and Magnetism	302
12	Universe	328
13	Information and Communication Technology	339
14	Classification of Elements	363
15	Chemical Reaction	381
16	Gases	395
17	Metal and Non-metals	415
18	Hydrocarbon and its Compounds	426
19	Chemicals used in Daily Life	442

Chapter 1 — Scientific Learning

1.1 Introduction: What is Science?

Science (from Latin *scientia* — "knowledge") is the systematic study of the natural world through **observation** and **experiment**. It is not just a collection of facts; it is a *way of asking questions about nature and finding reliable answers*.

Science deals only with questions that can be **verified** by observation or experiment. Questions about values, ethics, or supernatural beliefs lie outside the domain of science.

Science is broadly divided into:

- **Natural sciences** — study natural phenomena (Physics, Chemistry, Biology, Earth science).
- **Social sciences** — study human society (sociology, psychology).
- **Formal sciences** — mathematics and logic.

For Grade 10 SEE, we study **Science and Technology** which combines Physics, Chemistry, Biology, and aspects of ICT, Astronomy, and Environmental science.

1.2 The Scientific Method

The **scientific method** is a step-by-step process scientists use to investigate natural phenomena. It is not rigid — scientists often go back and forth between steps — but the framework is the same:

Step 1 — Identify a Problem / Ask a Question Curiosity begins science. A good scientific question must be **specific** and **testable**. "Why is the sky blue?" is a good question. "Why is the sky beautiful?" is not, because "beautiful" cannot be measured.

Step 2 — Observation Using our senses (and instruments) to gather information about the problem. Observation can be:

- **Qualitative** — describing qualities (red, smooth, sweet).
- **Quantitative** — measuring quantities (10 cm, 50 °C, 3.5 g).

Example: Observing that plants near the window grow taller than those in the dark corner.

Step 3 — Form a Hypothesis A **hypothesis** is a *tentative, testable explanation* for an observation. It must be written so that it can be supported or disproved by an experiment.

Example: "Plants grow taller when they receive more sunlight."

Step 4 — Design and Perform an Experiment An experiment must be **controlled** — only one variable (the *independent variable*) is changed at a time, while all other factors (the *controlled variables*) are kept constant. The result that is measured is the *dependent variable*.

Example: Give different groups of plants different amounts of light, but same water, soil, temperature. Measure height after 2 weeks.

Step 5 — Analyse Results Collect data (numbers, observations). Use tables, graphs, and statistics to see patterns.

Step 6 — Draw a Conclusion Decide whether the results **support** or **reject** the hypothesis.

- If supported the hypothesis stands until new evidence contradicts it.
- If rejected revise the hypothesis and test again.

Step 7 — Theory or Law (if repeatedly confirmed)

- A **theory** is a well-tested explanation for a broad set of phenomena (e.g., *Cell Theory*, *Theory of Evolution*).
- A **law** is a statement that describes what *always* happens under certain conditions, but does not explain *why* (e.g., *Newton's Law of Gravitation*).

Problem
Observation
Hypothesis (testable prediction)
Controlled Experiment
Analyse Data (tables, graphs)
Conclusion
Supports Rejects revise & retest

1.3 Variables in an Experiment

Variable	Meaning	Example (plant growth)
Independent	The factor you change	Amount of sunlight
Dependent	The factor you measure	Height of plant
Controlled	Kept the same	Water, soil, temperature
Control group	The standard for comparison	Plant with normal sunlight

1.4 Measurement and SI Units

Science depends on **measurement**. To communicate results accurately, scientists worldwide use one common system: the **International System of Units (SI)** — adopted in 1960.

The Seven SI Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

All other units (like newton, joule, watt) are **derived** from these.

Common Prefixes

Prefix	Symbol	Factor	Meaning
tera	T	10 ¹²	trillion
giga	G	10 ⁹	billion
mega	M	10 ⁶	million

kilo	k	10 ³	thousand
hecto	h	10 ²	hundred
deca	da	10 ¹	ten
deci	d	10 ⁻¹	tenth
centi	c	10 ⁻²	hundredth
milli	m	10 ⁻³	thousandth
micro	μ	10 ⁻⁶	millionth
nano	n	10 ⁻⁹	billionth

Example conversions:

- 4.5 km = 4.5 × 1000 = **4500 m**
- 320 cm = 320 ÷ 100 = **3.20 m**
- 2.5 kg = 2.5 × 1000 = **2500 g**

1.5 Significant Figures

Significant figures tell us the *precision* of a measurement. They include **all the certain digits plus one estimated (uncertain) digit**.

Example: A ruler marked in mm, reading 4.53 cm — the '4' and '5' are certain, the '3' is estimated **3 significant figures**.

Rules for Counting Significant Figures

1. All non-zero digits are significant. (4.53 3)
2. Zeros *between* non-zero digits are significant. (405 3)
3. Leading zeros are *not* significant. (0.045 2)
4. Trailing zeros *after* a decimal point are significant. (4.50 3)
5. Trailing zeros in a whole number without a decimal are ambiguous.

1.6 Accuracy vs Precision

- **Accuracy** — how close a measurement is to the **true value**.
- **Precision** — how close repeated measurements are to **each other** (reproducibility).

You can be precise without being accurate (if the instrument is wrongly calibrated). Good science aims for **both**.

1.7 Scientific Instruments and Their Uses

Quantity	Instrument	Unit
Length	metre ruler, vernier calliper, screw gauge	m
Mass	beam balance, electronic balance	kg
Time	stopwatch, clock	s
Temperature	thermometer (Celsius / Kelvin)	°C / K
Volume	measuring cylinder, pipette, burette	m ³ / L
Electric current	ammeter	A
Potential difference	voltmeter	V
Force	spring balance	N

1.8 Errors in Measurement

Systematic errors — same direction every time (e.g., zero error in a scale). Reduce by *calibration*.

Random errors — vary in direction and size (e.g., reading a ruler slightly differently). Reduce by *taking many readings and averaging*. **Gross errors** — mistakes by the observer (e.g., misreading a number). Avoid by *care and double-checking*.

1.9 Technology and Society

Science produces **knowledge**; technology applies that knowledge to solve practical problems. The wheel, electricity, vaccines, the internet — all started as scientific understanding that became technology.

Technology also drives new science: microscopes opened biology, telescopes opened astronomy, particle accelerators open particle physics.

Modern issues where science and technology meet society include **climate change, genetic engineering, artificial intelligence, space exploration, and renewable energy**.

Chapter 2 — Classification of Living Beings

2.1 Why Classify?

Earth has an estimated **8.7 million species** (about 1.5 million have been formally named so far). Studying each one individually is impossible. **Classification** groups organisms based on shared features so that we can:

- Identify them easily.

- Study their relationships.
- Understand evolution.
- Communicate about them across languages.

2.2 History of Classification

Aristotle (384–322 BC) — first attempt; divided animals into "blooded" and "bloodless".

Carolus Linnaeus (1707–1778) — Swedish botanist; the father of modern taxonomy. Introduced the **binomial system** of naming and the hierarchy Kingdom Class Order Genus Species.

R.H. Whittaker (1969) — proposed the **Five-Kingdom Classification**, still widely taught:

- Monera, Protista, Fungi, Plantae, Animalia.

Carl Woese (1977) — later added a level above Kingdom: the **Domain** (Bacteria, Archaea, Eukarya).

2.3 Taxonomic Hierarchy

From broadest (most inclusive) to most specific:

Kingdom
Phylum (called Division in botany)
Class
Order
Family
Genus
Species

Mnemonic: King Philip Came Over For Good Spaghetti.

Example: Classification of Human

Rank	Name
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates

Family	Hominidae
Genus	<i>Homo</i>
Species	<i>sapiens</i>

So our scientific name is *Homo sapiens*.

2.4 Binomial Nomenclature

Every species has a **two-part Latin name**:

1. **Genus** name — capitalised.
2. **species** name — lowercase.

Both are **italicised** (or underlined when handwritten).

Examples:

- *Mangifera indica* — mango
- *Oryza sativa* — rice
- *Triticum aestivum* — wheat
- *Homo sapiens* — human
- *Felis domesticus* — cat
- *Canis familiaris* — dog
- *Bos taurus* — cow

Rules

- Latin or Latinised Greek.
- Universal — same name worldwide.
- The species name never used alone; always with the genus.

2.5 The Five-Kingdom Classification (Whittaker)

Basis of classification: **cell type**, **cell number**, and **mode of nutrition**.

Kingdom 1 — Monera

- **Cell type:** Prokaryotic (no true nucleus; genetic material free in cytoplasm).
- **Cell number:** Unicellular.
- **Mode of nutrition:** Autotrophic (some bacteria), Heterotrophic (most), or Chemosynthetic.
- **Examples:** Bacteria (*E. coli*, *Lactobacillus*), blue-green algae (cyanobacteria).
- **Key feature:** Cell wall made of peptidoglycan; no membrane-bound organelles.

Importance of bacteria:

- Decomposers — recycle nutrients.
- Nitrogen fixation — *Rhizobium* in root nodules of legumes.
- Food production — yogurt, cheese (*Lactobacillus*).
- Disease-causing (pathogenic) — TB, cholera, typhoid.
- Antibiotic production.
- Sewage treatment.

Kingdom 2 — Protista

- **Cell type:** Eukaryotic (true nucleus).
- **Cell number:** Mostly unicellular, some colonial (like *Volvox*).
- **Nutrition:** Autotrophic (algae) or Heterotrophic (protozoa).
- **Examples:** *Amoeba* (changes shape using pseudopodia), *Paramecium* (slipper-shaped, moves with cilia), *Euglena* (has chlorophyll + flagellum), *Plasmodium* (causes malaria).
- **Key feature:** Live in water or moist places.

Kingdom 3 — Fungi

- **Cell type:** Eukaryotic.
- **Cell number:** Mostly multicellular (yeast is unicellular).
- **Nutrition:** Heterotrophic, mainly **saprophytic** (absorb nutrients from dead matter); some parasitic.
- **Cell wall:** made of **chitin** (not cellulose).
- **Examples:** Mushroom (*Agaricus*), bread mould (*Rhizopus*), yeast (*Saccharomyces*), *Penicillium* (source of penicillin).
- **Structure:** Thread-like body called **mycelium** made of **hyphae**.
- **Reproduction:** Spores (asexual) and sexual by fusion of hyphae.

Importance:

- Decomposers in ecosystem.
- Food (mushroom, yeast in baking).
- Medicine (penicillin).
- Spoilage of food.
- Some cause diseases (athlete's foot, ringworm).

Kingdom 4 — Plantae

- **Cell type:** Eukaryotic.
- **Cell number:** Multicellular.
- **Nutrition:** Autotrophic (photosynthesis).

- **Cell wall:** Cellulose.
- **Examples:** Mango, fern, moss, pine, etc.

Sub-groups (in increasing complexity):

Group	Body	Vascular tissue	Seeds	Examples
Algae (often under Protista)	Simple, mostly aquatic	Absent	No	<i>Spirogyra</i> , <i>Chara</i>
Bryophyta (mosses)	Small, leafy	Absent	No	Moss, <i>Funaria</i>
Pteridophyta (ferns)	Larger, true leaves	Present	No	Fern, <i>Pteris</i>
Gymnospermae	Woody, cones	Present	Naked seeds	Pine, <i>Cycas</i>
Angiospermae (flowering)	Diverse	Present	Seeds enclosed in fruit	Mango, rice

Angiospermae are divided into:

- **Monocots** — one cotyledon, parallel veins, fibrous root, flower parts in 3s (rice, wheat, maize, bamboo).
- **Dicots** — two cotyledons, net-like veins, tap root, flower parts in 4s or 5s (mango, pea, sunflower).

Kingdom 5 — Animalia

- **Cell type:** Eukaryotic.
- **Cell number:** Multicellular.
- **Nutrition:** Heterotrophic (ingest food).
- **No cell wall.**

Major phyla:

Phylum	Key feature	Examples
Porifera	Pore-bearers; sponges; no true tissues	<i>Spongilla</i> , <i>Sycon</i>
Coelenterata (Cnidaria)	Stinging cells (cnidocytes); radial symmetry	Hydra, jellyfish, coral
Platyhelminthes	Flat body, dorsoventrally flattened	Planaria, tapeworm, liver fluke
Nematoda	Round, cylindrical, unsegmented	<i>Ascaris</i> , hookworm

Annelida	Segmented body (metameres); closed circulation	Earthworm, leech, <i>Nereis</i>
Arthropoda	Jointed legs; exoskeleton of chitin	Insects, spider, crab, centipede
Mollusca	Soft body, often with shell; muscular foot	Snail, octopus, slug
Echinodermata	Spiny skin; radial symmetry (adult)	Starfish, sea urchin
Chordata	Notochord at some stage; dorsal nerve cord	Fish, frog, reptile, bird, mammal

Classes of Chordata (Vertebrates)

Class	Skin covering	Respiration	Reproduction	Examples
Pisces (fish)	Scales + mucus	Gills	Lay eggs (oviparous)	Rohu, shark
Amphibia	Moist skin	Gills (young), Lungs (adult)	Lay eggs in water	Frog, toad, salamander
Reptilia	Dry scales	Lungs	Lay eggs with shell	Snake, lizard, turtle, crocodile
Aves (birds)	Feathers	Lungs + air sacs	Lay calcareous eggs	Sparrow, eagle, penguin
Mammalia	Hair / fur	Lungs	Mostly viviparous (live young)	Human, dog, bat, whale

Key features of mammals

- Hair/fur on body.
- Mammary glands — produce milk to feed young.
- External ears (pinna).
- Four-chambered heart.
- Diaphragm present (separates thorax from abdomen).
- Most give birth to live young (viviparous); a few lay eggs (platypus, echidna).

2.6 Dichotomous Key

A **dichotomous key** is a tool that uses *pairs of contrasting statements* to identify an organism step by step.

Example (very simplified):

- 1 a. Has backbone go to 2
- b. No backbone INVERTEBRATE

- 2 a. Lives in water PISCES
- b. Lives on land go to 3

- 3 a. Body covered with scales REPTILE
- b. Body covered with feathers AVES
- c. Body covered with hair MAMMALIA

2.7 Viruses — A Special Case

Viruses are **not included** in any of the five kingdoms because they are **not truly living** outside a host cell. They have:

- A protein coat (**capsid**) around genetic material (DNA or RNA).
- No cytoplasm, no organelles, no metabolism on their own.
- Reproduce only inside a living host cell.

Examples: HIV, Influenza, COVID-19 (SARS-CoV-2), Tobacco mosaic virus, Bacteriophage.

Chapter 3 — Honey Bee

3.1 Introduction

The honey bee (*Apis indica* / *Apis mellifera*) is a **social insect** living in a colony of thousands. It is one of the most studied insects because of its economic importance (honey, wax) and its fascinating social behaviour.

Belongs to: Kingdom Animalia Phylum Arthropoda Class Insecta Order Hymenoptera Family Apidae.

3.2 Social Organization — Three Castes

A bee colony shows **polymorphism** (different body forms for different functions) and a strict **division of labour**.

Queen

- **One** per colony.
- Fertile female.

- Sole function: **lay eggs** (up to 1500–2000 per day in peak season).
- Develops from a fertilised egg fed exclusively on **royal jelly**.
- Larger abdomen; longer than workers.
- Has a sting but uses it mainly against rival queens.
- Mates once in her life with several drones (in flight) and stores sperm for years.

Drone

- **Hundreds** per colony (seasonal).
- Fertile **male**.
- Sole function: **mate with the queen**.
- Larger than workers; bigger eyes (to find queen in flight).
- No sting.
- Drones that fail to mate are expelled from hive before winter (and die).

Worker

- **Tens of thousands** per colony (20,000–80,000).
- **Sterile female** — cannot lay eggs (usually).
- Does **all the work** of the colony.
- Smallest in size.
- Has a barbed sting (used in defence; stinger often pulls out of body after stinging — bee dies).
- Develops from fertilised egg fed royal jelly only for 3 days, then nectar/pollen.

3.3 Division of Labour Among Workers (Age Polyethism)

Young workers do tasks inside the hive; older workers do outside tasks.

Age (days)	Job
1–3	Clean cells
4–6	Feed older larvae
7–12	Feed young larvae (nurse bees)
13–18	Build combs; receive nectar from foragers
19–21	Guard the hive entrance
22+	Forage for nectar, pollen, water, propolis

This shift in behaviour with age is called **age polyethism**.

3.4 Anatomy of a Worker Bee (External)

- **Head** — one pair of compound eyes (large, detect movement & colour), three simple eyes (ocelli, detect light intensity), one pair of antennae (smell & touch), mouth with mandibles (chew) and proboscis (suck nectar).
- **Thorax** — two pairs of membranous wings (fore & hind wings linked by hooks called **hamuli**); three pairs of jointed legs.
 - **Pollen basket (corbicula)** — on the outer surface of hind tibia; carries pollen.
 - **Pollen comb & brush** — on hind legs; collects pollen from body.
- **Abdomen** — sting at tip; wax glands (on ventral side of abdominal segments 4–7 in young workers); scent glands (Nasanov gland) for marking.

3.5 Lifecycle — Complete Metamorphosis

Four distinct stages:

Egg Larva Pupa Adult

- **Egg:** Queen lays one egg per cell, attached by a sticky secretion. Hatches in **3 days**.
- **Larva:** White, legless, worm-like. Fed by nurse bees — royal jelly for first 3 days, then pollen + nectar (mixture called "bee bread"). Grows rapidly, moults 5 times. Cell is sealed with wax cap when larva is ready to pupate. Larval stage ~**6 days**.
- **Pupa:** Inside sealed cell. Undergoes dramatic transformation (metamorphosis). About **12 days**.
- **Adult:** Chews out of cell. Total development time:
 - Queen: ~16 days
 - Worker: ~21 days
 - Drone: ~24 days

3.6 The Bee Hive (Comb)

A hive contains vertical **combs** made of **wax** secreted from the workers' abdominal glands. Each comb has thousands of hexagonal cells. The hexagonal shape is the most efficient packing (uses least wax for most storage).

Cells are of three types:

- **Brood cells** — for eggs and larvae.
- **Honey cells** — for storing honey.
- **Pollen cells** — for storing pollen.

Special **queen cells** (larger, peanut-shaped) hang vertically to raise a new queen when the old one is weak or the colony wants to swarm.

3.7 Food and Feeding

- **Nectar** (from flowers) converted into **honey** in the hive (water evaporated by fanning wings).
- **Pollen** stored as **bee bread** (protein source for larvae).
- **Water** — for cooling and diluting honey.
- **Royal jelly** — secretion from hypopharyngeal glands of young nurse bees; fed to all larvae for first 3 days, only to queen throughout life.
- **Propolis** — resin collected from tree buds; used to seal cracks and as antiseptic.

3.8 Communication — The Famous Bee Dances

Discovered by **Karl von Frisch** (Nobel Prize 1973). Bees communicate direction and distance of food source by dancing.

Round Dance

- Performed when food is **close** (less than ~100 m).
- Just runs in small circles, reversing direction.
- Tells others: "food is nearby".

Waggle (Figure-Eight) Dance

- Performed when food is **far** (more than ~100 m).
- Runs in a straight line **wagging abdomen**, then loops back.
- **Direction of straight run** (relative to vertical in dark hive) indicates **direction relative to the sun**.
- **Duration of waggle run** indicates **distance** to food.

This is one of the only known non-human **symbolic** communication systems.

3.9 Pollination — The Bee's Greatest Service

When a bee visits a flower for nectar, **pollen grains stick to its hairy body**. At the next flower, pollen rubs off onto the stigma **cross-pollination**.

Many crops depend almost entirely on bees:

- Apple, almond, mustard, sunflower, coffee, cucumber, watermelon.
- In Nepal: large cardamom, citrus, apple.

Economic value of bee pollination worldwide is many times greater than the value of honey itself.

3.10 Beekeeping (Apiculture)

Apiculture is the practice of rearing honey bees for honey, wax, and other products.

Tools used

- **Bee box** (Langstroth hive, invented 1852) — wooden boxes with movable frames.
- **Smoker** — puffs cool smoke to calm bees before opening hive.
- **Bee veil** — protects face.
- **Honey extractor** — centrifuge to pull honey out of comb without damaging it.
- **Hive tool** — to pry open frames.
- **Uncapping knife** — to remove wax cap from honey cells.

Steps in beekeeping

1. Site selection — flower-rich area, away from wind/predators.
2. Catching a swarm or buying a colony.
3. Regular inspection for disease, queen, food stores.
4. Harvesting honey 2–3 times a year (leave enough for the bees).

Honey extraction

- Uncap cells place frames in extractor centrifuge filter bottle.

3.11 Products from Bee Colony

Product	Source	Use
Honey	Nectar (processed)	Food, medicine
Beeswax	Wax glands of worker	Candles, polish, cosmetics, foundation sheets
Royal jelly	Hypopharyngeal gland	Health tonic, cosmetics
Propolis	Tree resins	Antiseptic, varnish
Bee venom	Sting	Treatment of arthritis (apitherapy)
Pollen	Flowers	Health food supplement

3.12 Threats to Bees

- **Pesticides** (especially neonicotinoids).
- **Habitat loss** — fewer wild flowers.
- **Climate change** — disrupts flowering time and bee activity.
- **Diseases & parasites** — *Varroa* mite, *Nosema* fungus.
- **Monoculture farming** — single crop means feast or famine.

Decline of bees threatens food security — this is why bees are sometimes called **"the most important workers on Earth"**.

Chapter 4 — Heredity

4.1 What is Heredity?

Heredity is the transmission of characteristics (traits) from parents to offspring. It is the reason children resemble their parents — yet they are not identical (because of **variation**).

The branch of biology dealing with heredity and variation is **Genetics**.

4.2 Key Vocabulary

Term	Meaning	Example
Trait / Character	A feature of an organism	Plant height, eye colour
Gene	Unit of heredity; a segment of DNA coding for a trait	Gene for tallness
Allele	Alternative forms of a gene	T (tall), t (short)
Dominant allele	Expresses even in heterozygous condition (capital letter)	T
Recessive allele	Expresses only in homozygous condition (lowercase)	t
Genotype	Genetic makeup of an organism	TT, Tt, tt
Phenotype	Observable trait	Tall or short
Homozygous	Both alleles same	TT or tt
Heterozygous	Two different alleles	Tt
Pure / True-breeding	Homozygous for the trait	TT or tt
Hybrid	Heterozygous; offspring of two pure parents differing in trait	Tt
F1 generation	First filial generation (offspring of parents)	Tt
F2 generation	Offspring of F1 × F1	TT, Tt, tt

P generation	Parental generation	TT × tt
--------------	---------------------	---------

4.3 Gregor Mendel — Father of Genetics

Gregor Mendel (1822–1884) was an Austrian monk who experimented with **garden pea** (*Pisum sativum*) for 8 years (1856–1864) in his monastery garden. He chose peas because:

- They have many clear, contrasting traits (tall/short, round/wrinkled seeds, etc.).
- They are easy to grow.
- They have a short life cycle.
- They can self-pollinate but also be cross-pollinated by hand.

He studied 7 traits, each with two contrasting forms. He counted thousands of plants and recorded the ratios carefully. This **quantitative approach** was revolutionary.

Mendel published his results in 1866, but they were ignored until **rediscovered in 1900** by three scientists (de Vries, Correns, von Tschermak).

4.4 The Seven Traits Mendel Studied

Trait	Dominant	Recessive
Plant height	Tall	Dwarf
Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Pod shape	Inflated	Constricted
Pod colour	Green	Yellow
Flower position	Axial	Terminal
Flower colour	Purple	White

4.5 Monohybrid Cross — One Trait at a Time

Example: Tall (TT) × Dwarf (tt)

Step 1: Parents

TT × tt

Gametes

T t

Step 2: F1

Tt (all TALL — Tall is dominant)

Step 3: F1 × F1

Tt × Tt

Gametes

T, t T, t

Step 4: F2

T t

T TT Tt

t Tt tt

Tall Tall Dwarf

- **Phenotypic ratio** in F2 = **3 Tall : 1 Dwarf**
- **Genotypic ratio** in F2 = **1 TT : 2 Tt : 1 tt**

4.6 Mendel's Laws

Law 1 — Law of Dominance

"In a cross between two pure organisms differing in a single trait, the F1 generation shows only the dominant trait. The recessive trait is masked but not lost."

Law 2 — Law of Segregation (Purity of Gametes)

"Each organism has two alleles for each trait. During gamete formation, the two alleles separate so that each gamete carries only one allele."

This explains why the recessive trait reappears in F2 — both parents (Tt) pass a 't' allele to some offspring.

Law 3 — Law of Independent Assortment

"Alleles of different traits assort independently of one another during gamete formation."
(Applies when following two traits at once — dihybrid cross.)

4.7 Dihybrid Cross — Two Traits at a Time

Example: Round-Yellow (RRYY) × Wrinkled-Green (rryy)

- Round (R) dominant over wrinkled (r); Yellow (Y) dominant over green (y).

F1: All **RrYy** (Round Yellow) — because of dominance.

F2 from RrYy × RrYy (a 4×4 Punnett square):

- **Phenotypic ratio = 9 : 3 : 3 : 1**
 - 9 Round Yellow
 - 3 Round Green
 - 3 Wrinkled Yellow

- 1 Wrinkled Green

This 9:3:3:1 ratio proves independent assortment.

4.8 Back Cross and Test Cross

- **Back cross** — cross between F1 hybrid and either of the parent ($Tt \times TT$ or $Tt \times tt$). Used to check the genotype of the F1.
- **Test cross** — cross between an organism of unknown genotype (e.g., Tall) and a homozygous recessive (tt). If any offspring is dwarf unknown was Tt (heterozygous); if all tall unknown was TT (homozygous dominant).

4.9 Incomplete Dominance (Beyond Mendel)

Sometimes neither allele is fully dominant — the F1 shows an **intermediate phenotype**.

Example: Red snapdragon (RR) $\times$ White snapdragon (WW) F1 all **Pink (RW)**. Selfing $RW \times RW$ gives F2: 1 Red : 2 Pink : 1 White (1 : 2 : 1, same as genotype ratio).

Other examples: Andalusian chickens (Black $\times$ White Blue), Four o'clock plants.

4.10 Sex Determination in Humans

- Humans have **46 chromosomes = 44 autosomes + 2 sex chromosomes**.
- Female: **44A + XX**
- Male: **44A + XY**

The **father** determines the sex of the child because he produces two kinds of sperm (50% carry X, 50% carry Y), while all eggs carry X.

	X	Y	sperm from father
X	XX	XY	eggs from mother (all X)
X	XX	XY	
	Girl	Boy	

- Probability: 50% girl, 50% boy (each pregnancy is independent).

4.11 DNA, Genes and Chromosomes

- **DNA** (Deoxyribonucleic Acid) is the molecule that carries genetic information. It is shaped like a **double helix** (Watson & Crick, 1953).
- Each DNA molecule is made of **nucleotides**, each containing:

- A sugar (deoxyribose)
- A phosphate group
- One of four bases: **A**denine, **T**hymine, **G**uanine, **C**ytosine.
- Bases pair specifically: **A with T, G with C**.
- A **gene** is a specific stretch of DNA that codes for a protein (and hence a trait).
- Genes are arranged linearly on **chromosomes**. Each chromosome has thousands of genes.
- Humans have ~**20,000–25,000 genes** on 23 pairs of chromosomes.

4.12 Mutations

A **mutation** is a sudden, permanent change in the DNA sequence. Mutations are the **raw material for evolution**.

Types

- **Gene mutation** — change in one or a few base pairs (e.g., sickle cell anaemia).
- **Chromosomal mutation** — change in number or structure of chromosomes (e.g., Down syndrome — extra chromosome 21).
- **Genomic mutation** — change in number of whole chromosome sets (polyploidy — common in plants).

Causes (Mutagens)

- **Radiation** — UV rays, X-rays, gamma rays.
- **Chemicals** — benzene, formaldehyde, certain pesticides.
- **Biological agents** — some viruses.
- **Errors in DNA replication** during cell division.

Mutations can be **harmful** (most), **neutral**, or **beneficial** (rare).

4.13 Genetic Disorders

Disorder	Cause	Symptoms
Haemophilia	X-linked recessive; defect in clotting factor	Excessive bleeding from minor cuts
Sickle cell anaemia	Gene mutation on chromosome 11	RBCs become sickle-shaped; pain, anaemia
Colour blindness	X-linked recessive	Cannot distinguish red-green
Down syndrome	Trisomy 21 (extra chromosome 21)	Mental retardation, characteristic face

Thalassaemia	Defect in haemoglobin gene	Severe anaemia
--------------	----------------------------	----------------

Consanguineous marriages (marrying close relatives) increase the risk of recessive disorders.

4.14 Applications of Genetics

- **Plant breeding** — high-yielding, disease-resistant varieties (e.g., IR8 rice).
- **Animal breeding** — improved breeds of cattle, poultry.
- **Medicine** — gene therapy, diagnosis of genetic diseases.
- **Forensic science** — DNA fingerprinting to identify criminals, paternity.
- **Anthropology** — tracing human migrations through DNA.

Chapter 5 — Physiological Structure and Life Processes

5.1 Introduction

The human body is a complex machine made up of trillions of cells organised into **tissues** **organs** **organ systems**. All the systems work together to keep us alive — taking in food and oxygen, distributing energy, removing wastes, sensing the environment, and reproducing.

In this chapter we study the major systems one by one: **digestive, respiratory, circulatory, excretory, nervous, endocrine, skeletal, and muscular**.

5.2 The Digestive System

The digestive system breaks down the food we eat into small, soluble molecules that can be absorbed into the blood and used by cells.

Main parts of the human digestive system



(colon rectum)

|

Anus

Accessory organs: **salivary glands, liver, pancreas.**

Pathway and what happens at each stage

1. Mouth

- Teeth cut, tear, and grind food **mechanical digestion.**
- **Saliva** (from salivary glands) contains the enzyme **salivary amylase** (or ptyalin) that begins **chemical digestion of starch** into maltose.
- Tongue mixes food with saliva and rolls it into a ball (**bolus**) which is swallowed.

2. Oesophagus

- A muscular tube ~25 cm long.
- Food is pushed down by **peristalsis** — wave-like contraction of muscles (you can even swallow upside down!).
- A ring of muscle called the **cardiac sphincter** at the lower end prevents stomach acid from rising back.

3. Stomach

- A J-shaped muscular bag.
- Walls secrete **gastric juice** containing:
 - **HCl (hydrochloric acid)** — kills germs, activates pepsin.
 - **Pepsin** — digests proteins into peptides.
 - **Mucus** — protects stomach lining from acid.
- Food stays ~3–4 hours, churned into a semi-liquid paste called **chyme**.
- A **pyloric sphincter** controls release of chyme into the small intestine.

4. Small Intestine (~6 m long) The main site of digestion and absorption.

- **Duodenum** (first ~25 cm) — receives **bile** from the liver (stored in gall bladder) and **pancreatic juice** from the pancreas.
 - **Bile** emulsifies fats (breaks big fat drops into tiny droplets) — does not contain enzymes.
 - **Pancreatic juice** contains enzymes: **trypsin** (digests proteins), **amylase** (digests starch), **lipase** (digests fats).
- **Jejunum and ileum** — inner surface has millions of tiny finger-like projections called **villi** (singular: villus).
 - Villi increase surface area enormously for absorption.
 - Each villus contains a network of blood capillaries (for absorbing glucose, amino acids, salts, water) and a **lacteal** (lymph vessel for absorbing fats).

- The digested food passes through villi into blood and lymph.

5. Large Intestine (~1.5 m)

- **Colon** absorbs water and salts from undigested matter.
- Many bacteria live here and produce **vitamin K** and some **B vitamins** (helpful symbiosis).
- **Rectum** stores the undigested matter (**faeces**) until excretion.
- **Anus** — opening through which faeces are expelled (**egestion** — note: this is different from excretion).

Digestive enzymes summary

Enzyme	Source	Substrate	Product
Salivary amylase	Salivary glands	Starch	Maltose
Pepsin	Stomach	Proteins	Peptides
Trypsin	Pancreas	Proteins / peptides	Amino acids
Pancreatic amylase	Pancreas	Starch	Maltose
Lipase	Pancreas / small intestine	Fats	Fatty acids + glycerol
Maltase	Small intestine	Maltose	Glucose
Sucrase	Small intestine	Sucrose	Glucose + fructose
Lactase	Small intestine	Lactose	Glucose + galactose

Functions of the liver (additional)

- Bile production.
- Storage of glycogen, vitamins (A, D, E, K), iron.
- Detoxification of harmful substances (alcohol, drugs).
- Production of plasma proteins (albumin, clotting factors).
- Breakdown of old RBCs.

5.3 The Respiratory System

The respiratory system takes in **oxygen** (for cellular respiration to release energy from glucose) and removes **carbon dioxide** (a waste product).

Pathway of air

Nostrils nasal cavity pharynx larynx trachea bronchi
 bronchioles alveoli (in lungs)

- **Nasal cavity** — hairs and mucus filter, warm, and moisten air.
- **Larynx (voice box)** — contains vocal cords; speech.
- **Trachea (windpipe)** — has C-shaped cartilage rings that keep it open.
- **Bronchi** — two branches, one to each lung. Inside lungs they divide into smaller **bronchioles**, ending in clusters of **alveoli** (air sacs).
- **Alveoli** — millions of tiny balloon-like sacs, each only one cell thick, surrounded by blood capillaries. This is where gas exchange happens.

Mechanism of breathing

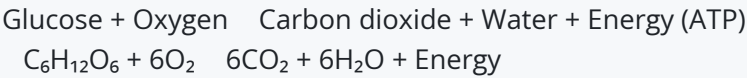
Step	Diaphragm	Rib cage	Chest volume	Air pressure	Air flow
Inhalation	Contracts, flattens	Moves up & out			Into lungs
Exhalation	Relaxes, domes up	Moves down & in			Out of lungs

(Diaphragm is a dome-shaped muscle separating thorax from abdomen. Intercostal muscles between ribs also help.)

Gas exchange in alveoli

- O₂ from alveolar air diffuses into blood capillaries binds to **haemoglobin** in RBCs.
- CO₂ from blood diffuses into alveoli exhaled.
- Alveoli are moist and have very thin walls efficient diffusion.

Cellular respiration (in cells)



Breathing rate

- Normal adult: 12–18 breaths/min.
- Increases during exercise (more O₂ needed, more CO₂ to remove).

Differences between inhaled and exhaled air

Gas	Inhaled air	Exhaled air
Oxygen	~21%	~16%
Carbon dioxide	~0.04%	~4%

Artery	Thick, elastic, muscular	None	Oxygenated (except pulmonary artery)	Heart body
Vein	Thin	Present	Deoxygenated (except pulmonary vein)	Body heart
Capillary	One cell thick	None	Exchange of materials	Artery cells vein

Blood — composition

Component	Function
Plasma (~55%)	Liquid matrix; carries nutrients, hormones, wastes, proteins
RBC (Red Blood Cells / Erythrocytes)	Carry O ₂ via haemoglobin; biconcave, no nucleus
WBC (White Blood Cells / Leukocytes)	Fight infection; engulf germs (phagocytosis)
Platelets (Thrombocytes)	Help in clotting at wounds

Haemoglobin — iron-containing red pigment in RBCs that binds O₂ to form **oxyhaemoglobin**: Hb + O₂ → HbO₂

Blood groups

- **ABO system**: A, B, AB (universal recipient), O (universal donor).
- **Rh factor**: positive or negative. Important in pregnancy (Rh incompatibility).

Lymphatic system

- A network of vessels carrying **lymph** (colourless fluid from tissue spaces) back to blood.
- **Lymph nodes** filter lymph and produce lymphocytes.
- Helps in immunity and absorption of fats (lacteals in villi).

5.5 The Excretory System

Excretion is the **removal of metabolic wastes** from the body. It is different from egestion (removal of undigested food).

Excretory organs and their wastes

Organ	Waste removed
--------------	----------------------

Kidneys	Urea, salts, excess water urine
Skin (sweat glands)	Water, salts, small amounts of urea sweat
Lungs	Carbon dioxide, water vapour
Liver	Bilirubin (from breakdown of haemoglobin) — in bile

Human urinary system

Kidney (×2) Ureter (×2) Urinary bladder Urethra

The nephron — functional unit of kidney

Each kidney has about **1 million nephrons**. Each nephron has:

- **Bowman's capsule** — cup-shaped end surrounding a knot of capillaries called the **glomerulus**.
- **Renal tubule** — long coiled tube surrounded by more capillaries.

Process of urine formation:

1. **Filtration** — blood is filtered in the glomerulus; water, urea, glucose, salts pass into Bowman's capsule **glomerular filtrate**.
2. **Reabsorption** — useful substances (glucose, most water, salts) are reabsorbed back into blood from the tubule.
3. **Secretion** — extra wastes (drugs, excess ions) are secreted into the tubule.
4. Urine formed contains **urea, salts, water**, and small amounts of other wastes.

Dialysis and kidney transplant

- If kidneys fail, an artificial **dialysis machine** filters blood regularly.
- A **kidney transplant** from a donor is the long-term solution.

5.6 The Nervous System

The nervous system controls and coordinates all body activities; it also allows us to sense and respond to the environment.

Main divisions

Nervous System

Central Nervous System (CNS)

Brain

Spinal cord

Peripheral Nervous System (PNS)

Somatic (voluntary)

Autonomic (involuntary)

Sympathetic

Parasympathetic

The Neuron (Nerve Cell) — the basic unit

Dendrites

\ | /

Cell
body

Nucleus

Axon

Axon
terminals

- **Dendrites** — receive signals.
- **Axon** — carries signal away.
- **Synapse** — tiny gap between neurons where a chemical messenger (**neurotransmitter**) carries the signal across.
- **Myelin sheath** — fatty insulation around axon; speeds up signal.

The Brain (protected by skull + meninges + cerebrospinal fluid)

- **Cerebrum** — largest part; controls thinking, memory, senses, voluntary action, speech.
- **Cerebellum** — balance, posture, coordination of movement.
- **Medulla oblongata** — controls involuntary actions (breathing, heart beat).
- **Hypothalamus** — links nervous and endocrine systems; controls temperature, hunger, thirst.
- **Pituitary gland** hangs below it.

The Spinal Cord

- Runs inside the vertebral column.
- Carries messages between brain and body.
- Controls **reflex actions** (rapid, automatic responses that don't involve the brain).

Reflex arc — the path of a reflex

Stimulus Receptor Sensory neuron Spinal cord Motor neuron Effector (muscle) Response

Example: touching a hot object hand pulls back immediately.

Sense organs

- **Eye** — photoreceptors (rods for dim light, cones for colour) on **retina**.
- **Ear** — cochlea (hearing), semicircular canals (balance).
- **Nose** — olfactory receptors (smell).
- **Tongue** — taste buds (taste).
- **Skin** — touch, pressure, pain, temperature.

5.7 The Endocrine System

The endocrine system consists of **glands** that secrete **hormones** directly into the blood. Hormones are chemical messengers that travel to **target organs** to produce a specific effect.

Major endocrine glands and their hormones

Gland	Hormone(s)	Function
Pituitary (master gland)	GH, TSH, ACTH, FSH, LH, prolactin, ADH, oxytocin	Controls other glands; growth; water balance; childbirth
Thyroid	Thyroxine (T ₃ , T ₄)	Regulates metabolism; deficiency causes goitre (iodine deficiency)
Parathyroid	Parathormone	Regulates calcium and phosphorus
Pancreas (islets of Langerhans)	Insulin (β cells), Glucagon (α cells)	Insulin lowers blood glucose; glucagon raises it
Adrenal	Adrenaline (epinephrine), Cortisol	Fight-or-flight; stress response
Testes ()	Testosterone	Male secondary sexual characters; sperm production
Ovaries ()	Oestrogen, Progesterone	Female secondary sexual characters; menstrual cycle; pregnancy

Diabetes mellitus

- Caused by **insulin deficiency** or resistance.
- Blood glucose rises; spills into urine.
- Symptoms: excessive thirst, frequent urination, weight loss.
- Treatment: insulin injection (Type 1), diet & exercise (Type 2).

Differences between nervous and endocrine control

Feature	Nervous	Endocrine
Signal	Electrical impulses	Hormones (chemicals)
Speed	Very fast (ms)	Slower (seconds–hours)
Duration	Short-lived	Long-lasting
Pathway	Along nerves	Through blood
Effect	Localised	Widespread

5.8 The Skeletal System

Humans have **206 bones** in the adult skeleton (about 270 at birth, many fuse).

Main functions

1. **Support** — gives the body its shape.
2. **Protection** — skull protects brain; ribs protect heart and lungs; vertebrae protect spinal cord.
3. **Movement** — bones act as levers; joints allow movement; muscles pull on bones.
4. **Blood cell formation** — **red bone marrow** in spongy bone produces RBCs, WBCs, platelets.
5. **Mineral storage** — calcium, phosphorus.

Types of bones

- **Long** — femur, humerus (act as levers).
- **Short** — carpals, tarsals.
- **Flat** — skull, ribs, scapula (protection).
- **Irregular** — vertebrae.

The skeleton (two parts)

- **Axial skeleton** — skull, vertebral column, ribs, sternum.
- **Appendicular skeleton** — limbs + girdles (pectoral + pelvic).

Joints — where two bones meet

- **Fixed / immovable** (e.g., skull sutures).
- **Slightly movable** (e.g., between vertebrae).
- **Freely movable (synovial)** — ball-and-socket (shoulder, hip), hinge (elbow, knee), pivot (neck), gliding (wrist).

Synovial joints have **synovial fluid** for lubrication and are surrounded by a **ligament** (bone-to-bone) and **tendon** (muscle-to-bone).

5.9 The Muscular System

About **600 muscles** in the human body, making up ~40% of body weight.

Three types of muscle

Type	Control	Structure	Location	Striations	Example
Skeletal (striated)	Voluntary	Long, cylindrical, multinucleate	Attached to bones	Yes	Biceps
Smooth (visceral)	Involuntary	Spindle-shaped, single nucleus	Gut, blood vessels, uterus	No	Intestine wall
Cardiac	Involuntary	Branched, intercalated discs	Heart only	Yes (faint)	Heart muscle

How muscles work

- Muscles can only **pull**, not push.
- They usually work in **antagonistic pairs** — e.g., biceps (flexes arm) and triceps (extends arm).
- A muscle contracts when its nerve sends an impulse; energy comes from ATP (made from glucose using oxygen).

Movement at a joint — example: bending the arm

- **Biceps** contracts arm bends (flexion).
- **Triceps** contracts arm straightens (extension).
- This is **antagonistic muscle action**.

Exercise effects on muscles

- Regular exercise makes muscles stronger and more efficient.
- Lack of use muscles waste away (**atrophy**).

5.10 Coordination of Systems

All systems work together. For example, when you run:

- **Muscular** system uses more energy.
- **Respiratory** system breathes faster (more O₂ in).
- **Circulatory** system pumps faster (delivers O₂, removes CO₂).
- **Skin** sweats (cools the body).
- **Nervous & endocrine** systems coordinate everything.

This harmony is what keeps us alive and healthy.

Chapter 6 — Nature and Environment

6.1 What is the Environment?

The **environment** is everything that surrounds a living organism and influences its life — the air, water, soil, sunlight, other organisms, and all physical conditions.

It has two components:

- **Abiotic (non-living)** — air, water, soil, sunlight, temperature, minerals.
- **Biotic (living)** — plants, animals, microbes, human beings.

Ecology is the branch of biology that studies the relationship between organisms and their environment.

6.2 Ecosystem

An **ecosystem** is a community of living organisms interacting with each other and with their non-living environment as a system.

Examples: a pond, a forest, a grassland, a desert, a coral reef, even a small puddle of water.

Components of an ecosystem

- Ecosystem
- Abiotic (non-living)

Sunlight

Air (CO₂, O₂, N₂)

Water

Soil / minerals

Temperature, humidity
- Biotic (living)

Producers (autotrophs) — green plants, algae

Consumers (heterotrophs) — animals

Decomposers — bacteria, fungi

6.3 Producers, Consumers, Decomposers

Type	What they do	Examples
Producers	Make their own food by photosynthesis (autotrophs)	Grass, trees, algae
Consumers	Eat other organisms (heterotrophs)	Animals, humans

Decomposers	Break down dead bodies and waste; recycle nutrients	Bacteria, fungi
-------------	---	-----------------

Types of consumers:

- **Primary consumer (herbivore)** — eats producers. E.g., cow, deer, rabbit.
- **Secondary consumer (carnivore)** — eats primary consumers. E.g., frog, snake.
- **Tertiary consumer (top carnivore)** — eats secondary consumers. E.g., eagle, lion.
- **Omnivore** — eats both plants and animals. E.g., human, bear.
- **Scavenger** — eats dead animals. E.g., vulture, hyena.

6.4 Food Chain and Food Web

A **food chain** shows the straight-line transfer of food (energy) from one organism to the next in an ecosystem.

Example (grassland):

Grass Grasshopper Frog Snake Eagle
(producer) (primary) (secondary) (tertiary) (top)

Trophic levels:

- Trophic level 1: Producers
- Trophic level 2: Primary consumers (herbivores)
- Trophic level 3: Secondary consumers
- Trophic level 4: Tertiary consumers

Food web

In nature, organisms eat many things and are eaten by many. Interlinked food chains form a **food web**. Food webs are more realistic than simple chains.

Hawk
/ \
Snake Frog
\ / \
Mouse Insect
\ /
Grass

6.5 Energy Flow in an Ecosystem

Energy flows from the sun producers consumers decomposers back to environment (as heat).

The 10% Rule (Lindeman): Only about **10% of the energy** at one trophic level is passed to the next. The rest is lost as:

- Heat (from respiration, movement).
- Undigested parts (faeces).
- Used for life processes (growth, repair).

That is why food chains rarely have more than 4–5 levels — there simply isn't enough energy left.

Pyramid of energy is always upright (wide at bottom, narrow at top). **Pyramid of numbers** can be inverted (e.g., one tree supports many insects). **Pyramid of biomass** is mostly upright but can be inverted in some aquatic ecosystems.

6.6 Ecological Pyramids — Summary

Pyramid	Based on	Usually shape
Pyramid of numbers	Count of organisms	Often upright, sometimes inverted (tree insects)
Pyramid of biomass	Total dry weight at each level	Mostly upright; inverted in some aquatic ecosystems
Pyramid of energy	Energy at each level	Always upright

6.7 Nutrient Cycling (Biogeochemical Cycles)

Energy flows in one direction (sun → heat); **nutrients cycle** through the ecosystem — they are reused again and again.

Water Cycle



Key terms: **Evaporation** (water → vapour), **Transpiration** (water from plants → vapour), **Condensation** (vapour → water droplets in clouds), **Precipitation** (rain, snow), **Runoff / Infiltration**.

Carbon Cycle

- Plants take CO₂ from atmosphere photosynthesis make glucose.
- Animals eat plants respiration returns CO₂.
- Decomposers break down dead matter CO₂ released.
- Fossil fuels (coal, oil, gas) burning CO₂ released.
- Oceans absorb CO₂.

Nitrogen Cycle

- 78% of air is nitrogen (N₂), but most organisms can't use it directly.
- **Nitrogen fixation** — *Rhizobium* bacteria in legume roots, lightning convert N₂ to nitrogen compounds.
- Nitrification — ammonia nitrites nitrates (by soil bacteria).
- Plants absorb nitrates make proteins.
- Animals eat plants proteins.
- Death decomposers ammonia repeat.

6.8 Biodiversity

Biodiversity = variety of life on Earth — variety of species, genes, and ecosystems.

Three levels:

- **Genetic diversity** — different genes within a species.
- **Species diversity** — number of different species.
- **Ecosystem diversity** — different habitats.

Why is biodiversity important?

- Provides food, medicine, oxygen, raw materials.
- Stabilises ecosystems (more species = more resilient).
- Aesthetic and cultural value.
- Each species is a result of millions of years of evolution — losing one is irreversible.

Hotspots of biodiversity

Areas with very high biodiversity but threatened by human activity. Nepal contains parts of two global hotspots:

- **Eastern Himalayas** (eastern Nepal).
- **Hindu Kush–Himalayas**.

Nepal's biodiversity includes: Bengal tiger, one-horned rhino, red panda, snow leopard, gharial, 850+ bird species, 6000+ plant species.

6.9 Threats to Biodiversity

1. **Habitat loss** — deforestation, urbanisation.
2. **Pollution** — air, water, soil.
3. **Climate change** — global warming.
4. **Overexploitation** — hunting, fishing, logging.
5. **Invasive species** — alien species outcompeting natives.
6. **Poaching and illegal wildlife trade.**

6.10 Conservation of Biodiversity

In-situ conservation (in original habitat)

- **National parks** — e.g., Chitwan, Sagarmatha, Banke, Bardiya.
- **Wildlife reserves** — e.g., Parsa, Shuklaphanta.
- **Conservation areas** — e.g., Annapurna, Manaslu.
- **Hunting reserves.**
- **Biosphere reserves** — e.g., Chitwan.

Nepal has 12 national parks, 1 wildlife reserve, 6 conservation areas, 13 buffer zones covering ~23% of the country.

Ex-situ conservation (outside habitat)

- **Zoos** — captive breeding.
- **Botanical gardens** — plant conservation.
- **Seed banks / gene banks** — store seeds for future.
- **Tissue culture** — grow plants from small samples.

International efforts

- **CITES** (Convention on International Trade in Endangered Species).
- **CBD** (Convention on Biological Diversity).
- **IUCN Red List** — classifies species as Least Concern, Vulnerable, Endangered, Critically Endangered, Extinct.
- **WWF** (World Wildlife Fund).
- **Ramagar Convention** — wetlands.

Community-based conservation in Nepal

- **Community forests** — handed over to local communities.
- **Buffer zone** management.

- **Anti-poaching units.**
- **Crane conservation centre** (Lumbini) for sarus crane.

6.11 Environmental Pollution

Air pollution

- Causes: vehicle exhaust, factory smoke, burning of fossil fuels, crop burning.
- Pollutants: SPM (suspended particulate matter), SO₂, NO₂, CO, ozone.
- Effects: respiratory diseases, acid rain, smog, global warming.
- Control: cleaner fuels, filters, planting trees, electric vehicles.

Water pollution

- Sources: industrial waste, sewage, pesticides, oil spills.
- Effects: kills aquatic life, spreads water-borne diseases (cholera, typhoid).
- Control: treatment of sewage before discharge, ban on harmful chemicals, public awareness.

Soil pollution

- Sources: pesticides, plastic, industrial waste, over-use of fertilisers.
- Effects: reduced fertility, contamination of food.
- Control: organic farming, proper waste disposal, use of biofertilisers.

Noise pollution

- Sources: traffic, loudspeakers, factories, construction.
- Effects: hearing loss, stress, sleep disturbance.
- Control: silencers, green belts, time restrictions on loudspeakers.

6.12 Greenhouse Effect and Global Warming

Greenhouse gases (CO₂, CH₄, N₂O, water vapour) trap heat reflected from the Earth's surface and keep the planet warm. This natural effect is good — without it Earth would be –18 °C instead of +15 °C.

Global warming = increase in greenhouse gases due to human activity (mainly burning fossil fuels, deforestation).

Effects:

- Polar ice melting sea level rise floods in low-lying areas.
- More extreme weather (heat waves, floods, cyclones).
- Species extinction (coral bleaching, polar bears, etc.).

- Changed rainfall patterns agriculture affected.
- Spread of tropical diseases.

Control:

- Reduce fossil fuel use shift to renewable energy (solar, wind, hydro).
- Plant more trees (afforestation).
- Use energy-efficient appliances.
- Public transport, cycling.
- International agreements (Paris Agreement, 2015).

6.13 Acid Rain

When SO₂ and NO₂ from industries mix with rain, they form **acid rain** (pH below 5.6).

- Damages buildings (especially marble — Taj Mahal yellowing).
- Kills aquatic life.
- Damages forests and crops.

Control: use low-sulphur fuels, install scrubbers in chimneys, switch to cleaner energy.

6.14 Ozone Layer Depletion

The **ozone layer** (O₃) in the stratosphere absorbs harmful **UV rays** from the sun.

- **CFCs** (chlorofluorocarbons, used in old fridges, aerosols) break down ozone.
- Thinning more UV skin cancer, cataracts, harm to crops and plankton.
- **Montreal Protocol (1987)** phased out CFCs ozone layer is slowly recovering.

6.15 Sustainable Development

Sustainable development = development that meets today's needs without compromising the ability of future generations to meet theirs.

Three pillars:

- **Economic** growth.
- **Social** equity.
- **Environmental** protection.

Key ideas: renewable resources, recycling, afforestation, clean energy, eco-friendly technology.

6.16 Waste Management

3 R's: Reduce, Reuse, Recycle.

Methods:

- **Composting** — kitchen & garden waste.
- **Vermicomposting** — using earthworms.
- **Biogas plants** — anaerobic digestion → methane fuel.
- **Segregation** at source — wet/dry, biodegradable/non-biodegradable.
- **Sanitary landfills** — engineered disposal sites.
- **Incineration** — burning of waste (last resort, pollutes).

Hazardous waste (chemicals, batteries, medical waste) needs special treatment — not just thrown away.

6.17 Environmental Legislation in Nepal

- **Environment Protection Act, 2076 (2019)**
- **Forest Act, 2076**
- **Solid Waste Management Act, 2068**
- **National Climate Change Policy, 2076**
- **Nepal's NDC (Nationally Determined Contribution)** — commitment under Paris Agreement to reduce emissions.

6.18 Role of an Individual

Every student can:

- Plant trees.
- Save water and electricity.
- Avoid plastic.
- Walk or cycle for short distances.
- Spread awareness.
- Join local conservation efforts.

Chapter 7 — Motion and Force

7.1 What is Motion?

An object is in **motion** when its position changes with respect to a fixed reference point (called the **reference frame**) over time.

A body at **rest** stays at rest; a body in motion stays in motion — unless acted on by an external force. This is **Newton's First Law** (the law of inertia).

Types of motion:

- **Translational** (straight line / curved).
- **Rotational** (about an axis — fan, earth).
- **Oscillatory / vibratory** (back and forth — pendulum).
- **Random** (Brownian motion — dust particles in sunlight).

7.2 Distance and Displacement

	Distance	Displacement
Definition	Total length of path travelled	Shortest distance between start and end, with direction
Type	Scalar (only magnitude)	Vector (magnitude + direction)
Can be zero?	Never zero if body moves	Can be zero if body returns to start
Sign	Always positive	Positive or negative

Example: Walk 4 m east then 3 m west.

- Distance = $4 + 3 = \mathbf{7\ m}$
- Displacement = $4 - 3 = \mathbf{1\ m\ east}$

7.3 Speed and Velocity

- **Speed** = distance / time (scalar, SI unit m/s).
- **Velocity** = displacement / time (vector, SI unit m/s).

Average speed = total distance / total time. **Instantaneous speed** = speed at a particular instant.

7.4 Acceleration

Acceleration = change in velocity / time taken.

- Vector quantity, SI unit m/s^2 .
- Can be **positive** (speeding up) or **negative** (slowing down — sometimes called **deceleration** or **retardation**).

If a body moves with uniform acceleration from velocity u to v in time t : $\mathbf{a = (v - u) / t}$

7.5 Equations of Uniform Motion (from rest)

If initial velocity $u = 0$, then:

- $v = u + at$ $v = at$
- $s = ut + \frac{1}{2} at^2$ $s = \frac{1}{2} at^2$
- $v^2 = u^2 + 2as$ $v^2 = 2as$

These three are called **equations of motion** (kinematic equations).

7.6 Graphical Representation

- **Distance-time graph** for uniform speed straight line.
 - Slope = speed.
- **Velocity-time graph** for uniform acceleration straight line.
 - Slope = acceleration.
 - Area under graph = distance travelled.

7.7 Force

Force is a push or pull that can change the state of motion or shape of an object.

- Vector quantity, SI unit = **Newton (N)**.
- 1 N = force needed to accelerate 1 kg mass by 1 m/s².

Effects of force:

- Can set a stationary body in motion.
- Can stop a moving body.
- Can change speed of a moving body.
- Can change direction of motion.
- Can change shape (deformation).

7.8 Newton's Laws of Motion

First Law (Law of Inertia)

A body at rest stays at rest, and a body in motion stays in uniform motion in a straight line, unless acted upon by an external unbalanced force.

- **Inertia** = tendency of a body to resist change in motion.
- Mass is a measure of inertia.

Second Law

The rate of change of momentum of a body is directly proportional to the net force applied, and takes place in the direction of the force. **F = m × a** (force = mass × acceleration)

Third Law (Action–Reaction)

For every action, there is an equal and opposite reaction.

- Action and reaction act on different bodies.
- Example: rocket propulsion, walking (foot pushes ground backward, ground pushes foot forward).

7.9 Momentum

Momentum (p) = mass × velocity.

- Vector quantity, SI unit = kg·m/s.

Law of conservation of momentum:

In the absence of external forces, the total momentum before collision equals the total momentum after collision. $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Used to derive Newton's third law. Applied in rockets, collisions, recoil of guns.

7.10 Types of Forces

Type	Example
Contact force	Friction, normal force, tension, applied force
Non-contact (field) force	Gravity, magnetic, electric
Gravitational force	Weight = mg
Frictional force	Opposes motion between surfaces
Tension	Force in a stretched string
Spring force	Restoring force of a spring
Buoyant force	Upward push by a fluid
Electrostatic	Between charged bodies
Magnetic	Between magnets

7.11 Friction

Friction = force that opposes relative motion between two surfaces in contact.

Causes: surface roughness, interlocking of microscopic bumps.

Effects:

- Necessary — lets us walk, brakes work, holds nails.
- Wasteful — wears out machines, produces heat.

Types:

- **Static friction** — body at rest.
- **Sliding / kinetic friction** — body sliding.
- **Rolling friction** — body rolling (smallest).
- **Fluid friction** — in liquids/gases (drag).

Factors affecting friction:

- Roughness of surfaces.
- Force pressing surfaces together (normal force).

Reducing friction: lubrication, polishing, ball bearings, using wheels, streamlining (in fluids).

Increasing friction: making surface rough (tyres, shoe soles), using brake pads.

7.12 Inertia and Mass

- **Inertia** = resistance to change in motion.
- **Mass** is the measure of inertia.
- Heavier objects have more inertia — harder to start, harder to stop.
- Weight ($W = mg$) is different from mass — weight varies with gravity (g).

7.13 Work

Work is done when a force causes a displacement. $W = F \times s \times \cos \theta$ (θ = angle between force and displacement).

- Scalar, SI unit = **joule (J)**. $1 \text{ J} = 1 \text{ N}\cdot\text{m}$.

If $\theta = 0$ (force along motion): $W = Fs$. If $\theta = 90^\circ$ (force perpendicular to motion): $W = 0$.

7.14 Energy

Energy = ability to do work.

- Scalar, SI unit = joule (J).

Forms of energy:

- Kinetic energy (KE) — energy of motion.
- Potential energy (PE) — stored energy.
- Heat (thermal), light, sound, electrical, chemical, nuclear.

Kinetic Energy

$$KE = \frac{1}{2} mv^2$$

Potential Energy

Gravitational PE = mgh (mass $\times$ gravity $\times$ height) **Elastic PE = $\frac{1}{2} kx^2$** (spring)

Law of Conservation of Energy

Energy can neither be created nor destroyed; it can only be converted from one form to another. Total energy in an isolated system is constant.

Example: A ball thrown up — KE $\rightarrow$ PE $\rightarrow$ KE as it falls.

7.15 Power

Power = rate of doing work. **$P = W / t$**

- SI unit = **watt (W)**. 1 W = 1 J/s.
- 1 kilowatt (kW) = 1000 W; 1 horsepower (HP) $\approx$ 746 W.

Common electrical power ratings: bulb 60 W, fan 75 W, motor 1 HP (746 W).

7.16 Simple Machines

A **machine** is a device that makes work easier (by changing magnitude or direction of force).

Mechanical Advantage (MA) = Load / Effort **Velocity Ratio (VR)** = Distance moved by effort / Distance moved by load **Efficiency (η)** = (MA / VR) $\times$ 100%

Types of simple machines

- **Lever** — crowbar, seesaw, scissors (Class 1), wheelbarrow (Class 2), tongs (Class 3).
- **Pulley** — single fixed (changes direction), movable (gains force), block and tackle.
- **Inclined plane** — ramp, staircase.
- **Wedge** — axe, knife, nail.
- **Screw** — screw, bolt, jar lid.
- **Wheel and axle** — door knob, bicycle pedal.

Wheel and axle is also considered a modified lever.

7.17 Gravitational Force and Free Fall

- **Universal Law of Gravitation (Newton):** Every body attracts every other body with a force proportional to the product of their masses and inversely proportional to the square of the distance between them.
- $F = G m_1 m_2 / r^2$
- G = Universal Gravitational Constant = $6.674 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$.
- g (acceleration due to gravity) = $GM / R^2 \approx 9.8 \text{ m/s}^2$ near Earth's surface.

Free fall

When only gravity acts on an object (no air resistance), it accelerates at g .

- On the Moon, $g = 1.6 \text{ m/s}^2$ (so astronauts float).
- On Jupiter, $g \approx 25 \text{ m/s}^2$.

Mass vs Weight

- **Mass** = amount of matter (kg). Same everywhere.
- **Weight** = gravitational pull on mass (N). $W = mg$. Changes with location.

7.18 Pressure (brief, full in Chapter 8)

Pressure = Force / Area

- SI unit = **pascal (Pa)** = 1 N/m^2 .
- Sharp knife cuts easily — small area → large pressure.

Chapter 8 — Pressure

8.1 What is Pressure?

Pressure is the force acting perpendicularly per unit area. **Pressure (P) = Force (F) / Area (A)**

- Scalar quantity.
- SI unit = **pascal (Pa)** = 1 N/m^2 .
- $1 \text{ atm} = 101,325 \text{ Pa} \approx 100 \text{ kPa}$.

Pressure in everyday life

- A sharp knife cuts better — small area → more pressure.
- School bags have wide straps — bigger area → less pressure on shoulders.

- Camels have wide feet — less pressure on sand.
- Nails have pointed tips — high pressure to enter wood.

8.2 Pressure in Solids

Solids exert pressure on the surface they touch. Pressure depends on:

- The force applied.
- The area of contact.

A person weighing 600 N standing on one foot (area ~200 cm²) presses harder on the floor than lying down (area ~2000 cm²).

8.3 Pressure in Liquids (Hydrostatic Pressure)

Liquids exert pressure on the walls and bottom of the container, and on any object immersed.

Factors affecting liquid pressure

- **Depth** — deeper → more pressure.
- **Density of liquid** — denser → more pressure.
- **Acceleration due to gravity** — greater g → more pressure.

Formula: $P = \rho g h$ (where ρ = density, g = gravity, h = depth).

Pascal's Law (Pressure transmission in fluids)

Pressure applied to an enclosed fluid is transmitted equally and undiminished in all directions throughout the fluid.

Applications

- **Hydraulic lift / jack** — small force on small piston creates huge force on big piston.
- **Hydraulic brakes** — in cars, a small foot pressure stops a heavy vehicle.
- **Hydraulic press** — used to compress materials.

In a hydraulic system: $F_1 / A_1 = F_2 / A_2$

8.4 Buoyancy and Archimedes' Principle

When an object is placed in a fluid, the fluid pushes it **upward** with a force called **buoyant force** (or upthrust).

Archimedes' Principle

When a body is wholly or partially immersed in a fluid, it experiences an upward buoyant force equal to the weight of the fluid displaced.

Buoyant force, $F_b = \rho \times V \times g$ (where ρ = density of fluid, V = volume of fluid displaced = volume of submerged part of body, g = gravity).

Three cases when an object is placed in a fluid

Condition	Result
Weight > Buoyant force	Object sinks (density of object > density of fluid)
Weight = Buoyant force	Object floats (just below/at surface)
Weight < Buoyant force	Object risks up and partially floats

In short:

- **Sinks** if density of object > density of fluid.
- **Floats** if density of object < density of fluid.
- **Hovers** (suspended) if densities are equal.

Examples of buoyancy

- Iron nail sinks in water but floats in mercury (mercury is denser).
- Ships float because their average density (with air inside) is less than water.
- Submarines control buoyancy by filling/emptying ballast tanks.
- Hot-air balloons rise because hot air inside is less dense than cool air outside.

Why is the swimming pool floor less painful at depth?

Buoyant force reduces your apparent weight in water — easier to lift things underwater.

8.5 Density

Density (ρ) = mass / volume

- SI unit = **kg/m³** (or g/cm³ for small things).
- Water has density 1000 kg/m³ = 1 g/cm³.

Relative density = density of substance / density of water (no unit).

- Iron: 7.8 (sinks in water)
- Mercury: 13.6 (floats on water... no, iron sinks because iron's density > water)
- Wood (oak): 0.6–0.9 (floats)

8.6 Atmospheric Pressure

The Earth is surrounded by a thick layer of air called the **atmosphere**. The air has weight — exerts pressure on everything.

Atmospheric pressure at sea level $\approx 101,325 \text{ Pa} \approx 1 \text{ atm} \approx 760 \text{ mmHg}$.

This pressure is huge — about 10^5 N on every square metre. We don't feel it because the pressure inside our body equals the outside pressure.

Evidence of atmospheric pressure

- Drinking straw works — you suck air out, atmospheric pressure pushes the liquid up.
- Magdeburg hemispheres (1654) — two halves held together by atmosphere; even teams of horses couldn't pull them apart until air was let in.
- Sucking air out of a metal can — it crumples.

Instruments to measure atmospheric pressure

- **Mercury barometer** (Torricelli, 1643) — height of mercury column $\approx 76 \text{ cm} = 760 \text{ mm} = 1 \text{ atm}$.
- **Aneroid barometer** — uses a metal box with thin walls; no liquid.

Why mercury and not water in a barometer?

Mercury is very dense ($13.6 \times$ water). A water barometer would need to be $\sim 10.3 \text{ m}$ tall!

8.7 Variation of Atmospheric Pressure

- **Decreases with altitude** — air becomes thinner, fewer air molecules above.
- **Weather:** Low pressure — stormy/rainy weather. High pressure — clear skies.
- **Breathing at high altitude** is harder because oxygen partial pressure is lower.

8.8 Manometer — measures gas pressure

A U-tube partially filled with liquid. One end connected to gas, other open. Difference in liquid levels $\times$ density $\times g$ = gas pressure (above atmospheric).

8.9 Applications of Pressure Concepts

- **Syringe / pump** — push the plunger to increase pressure inside, fluid flows out.
- **Siphon** — atmospheric pressure pushes liquid up over a hump.
- **Aeroplane wings** — shaped so air moves faster above than below — lower pressure above — lift.
- **Bunsen burner** — gas pressure forces gas out; air mixes at the base.
- **Vacuum cleaner** — low pressure inside sucks dust in.

- **Blood pressure** — measured with sphygmomanometer (in mmHg).

8.10 Pressure in Gases

Gas molecules move randomly and hit the walls of the container → gas pressure.

- Higher temperature → faster molecules → more pressure.
- More gas in same volume → more pressure.
- Smaller volume → more pressure (gas compressed).

These are Boyle's law and Charles's law (covered in detail in Chapter 16).

Chapter 9 — Heat

9.1 Heat and Temperature — What's the Difference?

	Heat	Temperature
Definition	Form of energy that flows from hot to cold	Degree of hotness/coldness of a body
SI unit	Joule (J)	Kelvin (K) (also °C)
Cause	Total kinetic energy of molecules	Average kinetic energy of molecules
Flows?	Yes (hot → cold)	No (it is a property)
Measured by	Calorimeter	Thermometer

A bathtub of warm water has more heat than a sparkler flame, even though the flame is hotter.

9.2 Temperature Scales

- **Celsius (°C)** — water freezes at 0 °C, boils at 100 °C (at 1 atm).
- **Fahrenheit (°F)** — used in USA; water freezes at 32 °F, boils at 212 °F.
- **Kelvin (K)** — SI unit; 0 K = absolute zero (where molecular motion stops).
 - $K = °C + 273$
 - $°C = K - 273$

Conversion

- $°F = (9/5 \times °C) + 32$
- $°C = (5/9) \times (°F - 32)$

9.3 Thermometers

A thermometer uses a property that changes with temperature:

- **Liquid-in-glass** — mercury or alcohol expands when heated. Mercury for higher temperatures (–39 to 357 °C); alcohol (coloured) for lower temperatures.
- **Clinical thermometer** — has a kink (constriction) so mercury doesn't flow back; reads 35–42 °C.
- **Bimetallic strip** — two metals expand differently — strip bends — used in thermostats.
- **Resistance thermometer / thermistor** — resistance changes with temperature.
- **Thermocouple** — voltage changes with temperature.

9.4 Specific Heat Capacity

Specific heat capacity (c) = heat required to raise the temperature of 1 kg of a substance by 1 K (or 1 °C).

Heat energy $Q = m \times c \times \Delta T$

where m = mass (kg), c = specific heat capacity (J/kg·K), ΔT = temperature change (K or °C).

Different substances have different specific heat capacities:

- Water has very high c (4200 J/kg·K) — water takes a long time to heat up and cool down. This is why water is used in car radiators and coastal climates are moderate.
- Metals have low c — heat up and cool down quickly.

9.5 Latent Heat

When a substance changes state (solid — liquid — gas), temperature stays constant during the change — but heat is still being absorbed or released.

Latent heat = heat required to change the state of 1 kg of a substance without changing its temperature.

- **Latent heat of fusion (L_f)** — solid — liquid (e.g., ice — water). L_f of ice = 334,000 J/kg.
- **Latent heat of vaporisation (L_v)** — liquid — gas (e.g., water — steam). L_v of water = 2,260,000 J/kg.

$Q = m \times L$

Why is L_v so much larger than L_f ? To completely separate molecules into gas, you must overcome all intermolecular forces, not just weaken them.

9.6 Heat Transfer — Three Modes

Conduction

- Heat passes through a material **without the material itself moving**.
- Fast in **solids** (especially metals = good **conductors**), slow in liquids and gases (poor **insulators**).
- **Metals** are good conductors because of free electrons.
- **Non-metals, wood, plastic, air, wool** are insulators.
- Examples: iron rod heated at one end; metal spoon in hot tea.

Why does wool keep us warm even though it's not "warm" itself? Wool traps air, and air is a poor conductor. So heat from our body cannot escape quickly.

Convection

- Heat transferred by **actual movement of the heated fluid** (liquid or gas).
- The hot part rises, cool part sinks — forms **convection currents**.
- Examples: sea breeze, land breeze, boiling water, room heater.

Sea breeze (day): Land heats faster than sea; hot air over land rises; cool air from sea flows in breeze from sea. **Land breeze (night):** Land cools faster; hot air over sea rises; cool air from land flows to sea.

Radiation

- Heat transferred as **electromagnetic waves (infrared); no medium required**.
- The Sun's heat reaches Earth by radiation (through vacuum).
- Dark, dull surfaces **absorb** and **emit** radiation well.
- Bright, shiny surfaces **reflect** radiation.
- A **thermos flask** uses all three: vacuum between walls (no conduction/convection) + silvered walls (no radiation).

Comparison

Mode	Medium	Speed	Direction
Conduction	Mostly solids	Slow	Through substance
Convection	Fluids	Faster	Bulk movement (circular)
Radiation	No medium needed	Fastest (speed of light)	In straight lines

9.7 Thermal Expansion

Most substances **expand when heated** and **contract when cooled**.

In solids

- **Linear expansion** — length increases. $\Delta L = \alpha L \Delta T$ (α = coefficient of linear expansion).
- Examples: railway tracks have gaps; bridges have expansion joints; bimetallic strips.

In liquids

- Real expansion = apparent expansion + expansion of container.
- Water has **anomalous expansion** between 0–4 °C: it **contracts** when heated from 0 to 4 °C, then expands normally above 4 °C. Water is densest at **4 °C**. This is why ice floats and aquatic life survives under frozen ponds.

In gases

- Gases expand most on heating (Charles's law, Chapter 16).

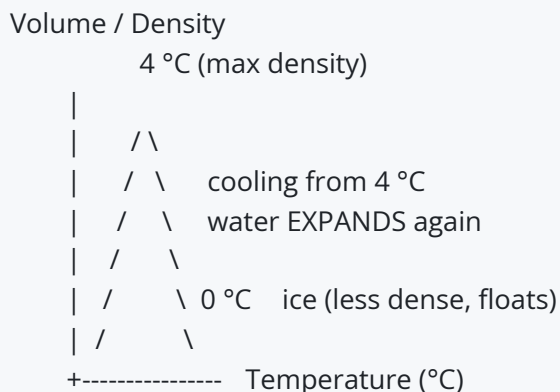
Applications

- **Thermostat** (iron + brass bimetallic strip).
- **Mercury / alcohol thermometer**.
- **Hot-water system** — expansion tank allows heated water to expand.
- **Ripple tank** uses water's expansion.

Problems

- Bridges buckle if no expansion gap.
- Pipes crack if water freezes and expands.

9.8 Anomalous Expansion of Water



- Water is densest at 4 °C.
- As water cools below 4 °C, it expands. Ice floats — insulating the water below so fish survive.
- This property is essential for life in cold climates.

9.9 Calorimetry

A **calorimeter** measures the amount of heat released or absorbed in a chemical or physical change.

Principle: Heat lost by hot body = Heat gained by cold body (in an isolated system). $m_1c_1(T_1 - T) = m_2c_2(T - T_2)$ where T is the final temperature.

Example: 200 g of water at 80 °C mixed with 300 g of water at 20 °C. Final temperature? $0.2 \times 4200 \times (80 - T) = 0.3 \times 4200 \times (T - 20)$ $160 - 2T = 3T - 60$ $5T = 220$ **T = 44 °C**

9.10 Newton's Law of Cooling

The rate of loss of heat of a body is directly proportional to the difference in temperature between the body and its surroundings.

$dQ/dt \propto (T - T_{\text{surrounding}})$

This is why hot tea cools fast at first and slowly later — as the temperature difference decreases, cooling slows.

9.11 Greenhouse Effect (revisited)

Covered in Chapter 6 — CO₂, CH₄, N₂O trap infrared radiation, keeping Earth warm.

9.12 Sources of Heat

- **Sun** (nuclear fusion).
- **Burning of fuels** (chemical energy → heat).
- **Electric heater** (electrical → heat).
- **Friction** (mechanical → heat).
- **Nuclear reactions** (nuclear → heat).

9.13 Effects of Heat

- Raises temperature.
- Causes expansion.
- Changes state (with latent heat).
- Causes chemical change (cooking, burning).
- Generates electricity (in power plants).

Chapter 10 — Wave

10.1 What is a Wave?

A **wave** is a disturbance that travels through a medium (or through space) carrying **energy** from one place to another, **without the transfer of matter**.

Example: A stone dropped in water creates ripples — water itself doesn't travel far, but energy does.

10.2 Types of Waves

Mechanical waves (need a medium)

- Sound waves, water waves, waves on a string, seismic waves.

Electromagnetic waves (no medium needed)

- Light, radio, X-rays, microwaves, infrared, UV, gamma rays.

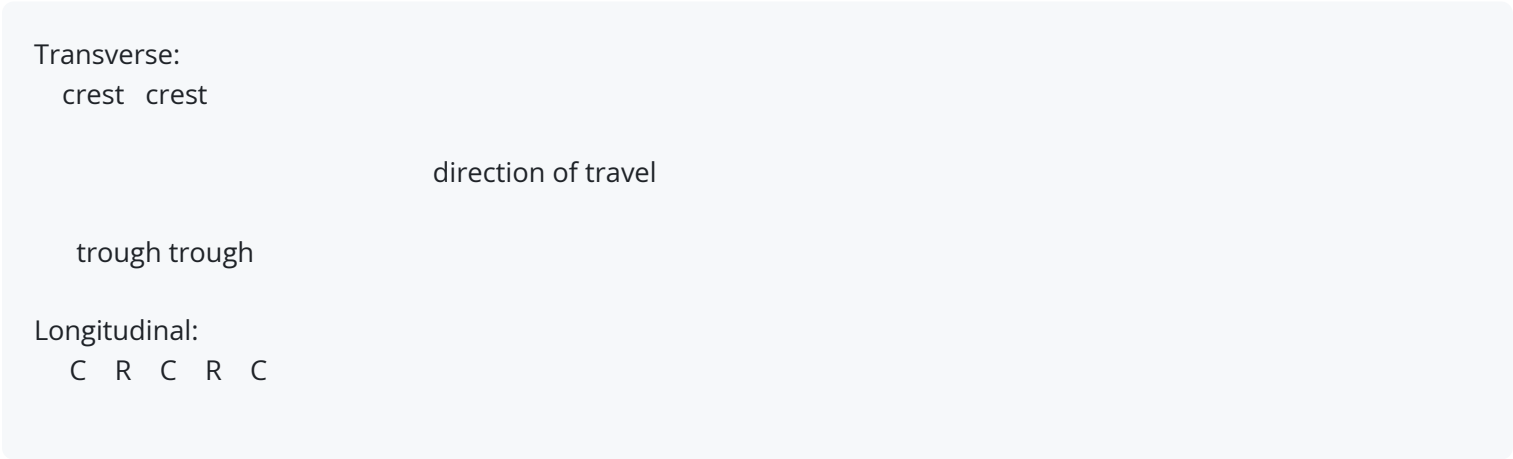
By motion of particles

Transverse wave — particles vibrate **perpendicular** to the direction of wave travel.

- Example: light wave, wave on a string, water surface wave.
- Has **crests** (high points) and **troughs** (low points).

Longitudinal wave — particles vibrate **parallel** to the direction of wave travel.

- Example: sound wave, P-wave in earthquake.
- Has **compressions** (regions of high density/pressure) and **rarefactions** (low density).



10.3 Wave Parameters

Parameter	Symbol	Unit	Definition
Wavelength	λ (lambda)	m	Distance between two consecutive crests (or compressions)
Frequency	f	Hz (hertz)	Number of waves passing a point per second

Time period	T	s	Time for one complete wave to pass
Amplitude	A	m	Maximum displacement from mean position
Speed	v	m/s	Distance travelled by a wave crest per second

Relationships

- $T = 1 / f$
- $v = f \times \lambda$ (wave equation — very important)

Example: Sound in air $v = 340$ m/s. If $f = 500$ Hz, $\lambda = 340/500 = 0.68$ m.

10.4 Sound Waves

- Longitudinal, mechanical, needs a medium (cannot travel through vacuum).
- Speed: ~340 m/s in air (at 20 °C), faster in solids, faster in liquids.
- Speed in air increases with temperature.

Medium	Approx speed (m/s)
Air (20 °C)	343
Water	1500
Steel	5000
Vacuum	0 (cannot travel)

Characteristics of sound

- **Pitch** — high or low; depends on frequency. (Whistle = high pitch; drum = low pitch.)
- **Loudness** — depends on amplitude. Louder = bigger amplitude.
- **Quality / Timbre** — distinguishes same note from different instruments (e.g., guitar vs piano).

Auditory range

- Human ear: 20 Hz – 20,000 Hz (20 kHz).
- Below 20 Hz: **infrasound** (felt, not heard) — elephants, earthquakes.
- Above 20,000 Hz: **ultrasound** (dogs, bats, dolphins). Used in sonar, medical imaging (ultrasound scans of babies), cleaning jewellery, breaking kidney stones.

Noise and Music

- **Noise** — irregular, unpleasant, no fixed pitch.

- **Music** — pleasant, regular vibrations with fixed pitch.

10.5 Reflection of Sound — Echo

When sound waves hit a hard surface (wall, cliff), they bounce back.

- **Echo** — the reflected sound, heard distinctly when the surface is at least 17.2 m away (so that the reflected sound reaches ear ≥ 0.1 s after the original).
- **Reverberation** — repeated reflections that cause the sound to persist (e.g., in a big empty hall). Reduced by soft, absorbent materials (carpets, curtains, acoustic tiles).

Applications of sound reflection

- Stethoscope.
- Hearing aid.
- SONAR (Sound Navigation and Ranging) — used to detect objects underwater. Time taken for echo + speed of sound in water = distance to object.
 - Depth of sea = $(v \times t) / 2$

10.6 Human Ear

Outer ear Ear canal Eardrum (vibrates) 3 tiny bones
(hammer, anvil, stirrup) Cochlea (in inner ear)
hair cells convert vibration to nerve signal
auditory nerve brain (interprets as sound)

10.7 Light — Electromagnetic Wave

Light is a transverse electromagnetic wave; it does not need a medium (it travels through vacuum at 3×10^8 m/s).

The visible spectrum (in order of wavelength): **VIBGYOR** — Violet, Indigo, Blue, Green, Yellow, Orange, Red.

- Violet: shortest wavelength, highest frequency.
- Red: longest wavelength, lowest frequency.

Reflection of Light

- **Law of reflection:**
 - i. Angle of incidence = angle of reflection ($i = r$).
 - ii. Incident ray, reflected ray, and normal all lie in the same plane.

Mirrors

Plane mirror

- Image is **virtual, erect, same size, laterally inverted**, as far behind as the object is in front.

Concave mirror (curved inward)

- Can form real or virtual images depending on object position.
- Used in: shaving mirror, dentist mirror, headlights, solar furnace.

Convex mirror (curved outward)

- Always forms a **virtual, erect, diminished** image.
- Used as rear-view mirror in vehicles (wider field of view).

Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ Magnification: $m = -\frac{v}{u} = \frac{h'}{h}$

Sign convention: distances measured from pole; real is positive (in front); virtual negative.

10.8 Refraction of Light

When light passes from one medium to another (e.g., air to glass), it **bends**.

Cause: speed of light changes in different media.

Laws of Refraction (Snell's Law)

- Incident ray, refracted ray, and normal all lie in the same plane.
- $\sin i / \sin r = \text{constant}$ (= refractive index, n).

Refractive Index

$n = \text{speed of light in vacuum} / \text{speed of light in medium} = c / v$

Or relative: ${}_1n_2 = \sin i / \sin r = v_1 / v_2$

Effects of refraction

- A coin in a cup appears higher when water is added.
- A pencil in a glass of water looks bent.
- The sky is blue, the sun is red at sunrise/sunset (scattering of light).

Total Internal Reflection

When light goes from denser to rarer medium (e.g., glass to air), at a certain angle called the **critical angle**, refraction becomes 90° . Beyond this, light reflects back into the denser medium — **total internal reflection**.

Used in:

- **Optical fibres** — light travels along thin glass fibres for communication (internet, telephone).
- **Mirage** in deserts.
- **Sparkle of diamond** — high refractive index, light totally internally reflected multiple times before exiting.

10.9 Lenses

A lens is a transparent medium bounded by two curved surfaces (or one curved + one plane).

Convex (converging) lens — thicker in middle. Brings light together (focus).

- Used in: magnifying glass, camera, projector, spectacles for hypermetropia (far-sighted), eyeglasses for presbyopia.

Concave (diverging) lens — thinner in middle. Spreads light out.

- Used in: spectacles for myopia (near-sighted), peephole in doors.

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ Magnification: $m = \frac{v}{u}$

Power of lens

P = 1/f (in metres); unit = **diopetre (D)**. A lens of focal length 50 cm has power $1/0.5 = +2 \text{ D}$ (convex) or -2 D (concave).

10.10 Dispersion of Light

When white light passes through a prism, it splits into seven colours — **VIBGYOR**. This is because different colours have different refractive indices (violet bends most, red bends least).

A **rainbow** is formed by dispersion of sunlight by raindrops (reflection + refraction + dispersion).

10.11 Scattering of Light

- Light scattering by tiny particles in the atmosphere.
- Shorter wavelengths (blue) scatter more → sky looks blue.
- At sunset, light passes through more atmosphere → blue scattered away → red/orange light reaches us → sun appears red.
- Tyndall effect — scattering of light by colloidal particles (e.g., sunlight in a forest, beam of light in a dusty room).

10.12 Electromagnetic Spectrum (in order of increasing wavelength / decreasing frequency)

Wave	Wavelength	Use / danger
γ-rays	$< 10^{-12}$ m	Cancer treatment; nuclear hazards
X-rays	10^{-10} m	Medical imaging (bones); harmful in excess
UV	10^{-8} m	Vitamin D synthesis; sunburn; skin cancer
Visible	10^{-6} m	Vision
IR	10^{-5} m	Remote control, thermal imaging, heaters
Microwaves	10^{-2} m	Cooking, mobile phones, radar
Radio	> 1 m	Broadcasting, communication

All EM waves travel at 3×10^8 m/s in vacuum.

10.13 Applications of EM Waves

- Radio: broadcasting, communication.
- Microwaves: cooking (water molecules vibrate), satellite communication.
- IR: night vision, remote control, thermography.
- Visible: photography, vision.
- UV: sterilisation, detecting forged bank notes, tanning.
- X-rays: radiography, CT scans, security scanners.
- γ-rays: cancer therapy, food preservation (kills microbes), sterilising equipment.

10.14 Communication Using Waves

- Wired (copper, optical fibre).
- Wireless (radio, microwaves, satellite).
- Mobile phones use microwaves; signals go to nearest tower → network → destination.

Chapter 11 — Electricity and Magnetism

11.1 Electric Charge

- **Charge** is a fundamental property of matter that causes it to experience a force when near other charges.

- Two types: **positive (+)** and **negative (-)**.
- Like charges repel, unlike charges attract.
- SI unit = **coulomb (C)**.
- Charge of one electron = $-1.6 \times 10^{-19} \text{ C}$ (smallest free charge).
- Charge is **conserved** — cannot be created or destroyed, only transferred.

Methods of charging

- **Friction** — rub a plastic comb on hair — comb gets negative charge (gains electrons from hair).
- **Conduction** — touch a charged body to a neutral one — charge spreads.
- **Induction** — bring a charged body near (without touching) — opposite charges accumulate on near side, like charges on far side. (Used in capacitors.)

Coulomb's Law

The force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

$$F = k \times q_1 q_2 / r^2 \text{ where } k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2.$$

11.2 Electric Field

- The region around a charge where its influence is felt is called an **electric field**.
- Represented by **field lines** — arrows from + to -.
- **Strength** $E = F / q$ (N/C or V/m).
- **Uniform field** between parallel plates.

11.3 Electric Potential and Potential Difference

- **Electric potential** at a point = work done in bringing a unit positive charge from infinity to that point.
- **Potential difference (V)** = work done per unit charge in moving a charge between two points.
- $V = W / q$ $W = qV$
- SI unit = **volt (V)**. $1 \text{ V} = 1 \text{ J/C}$.

A 9 V battery does 9 J of work per coulomb of charge moved through it.

11.4 Current

- **Electric current (I)** = rate of flow of charge.
- $I = Q / t$
- SI unit = **ampere (A)**. $1 \text{ A} = 1 \text{ C/s}$.
- Conventional current flows from + to - (in external circuit); electrons actually flow - to +.

- Measured with an **ammeter** (connected in **series**, low resistance).

Types of current

- **Direct current (DC)** — flows in one direction only. Batteries, solar cells.
- **Alternating current (AC)** — changes direction periodically. Mains supply in homes (~50 Hz in Nepal).

11.5 Voltage / EMF

- **EMF (electromotive force)** = energy supplied by the source per unit charge. Unit = volt.
- **Potential difference** across a component = energy used per unit charge passing through it.

11.6 Resistance and Ohm's Law

Resistance (R) = opposition to current flow. SI unit = **ohm (Ω)**.

Ohm's Law

At constant temperature, the current through a conductor is directly proportional to the potential difference across it. **$V = I \times R$**

A component obeying this is **ohmic** (e.g., metal wire at constant temp). Non-ohmic examples: filament bulb (resistance rises with temp), diode, transistor.

Factors affecting resistance

- **Length (l)** — longer → more resistance. $R \propto l$.
- **Cross-sectional area (A)** — thicker → less resistance. $R \propto 1/A$.
- **Material** — depends on **resistivity (ρ)**. $R \propto \rho$.
- **Temperature** — for metals, R increases with T; for semiconductors, R decreases.

$$R = \rho l / A$$

Resistivity and Conductivity

- **Resistivity (ρ)** — property of material. Unit: $\Omega \cdot m$.
- **Conductivity (σ)** = $1/\rho$. Unit: S/m (siemens per metre).

Material	Resistivity ($\Omega \cdot m$)
Silver	1.6×10^{-8} (best conductor)
Copper	1.7×10^{-8} (used in wires)
Aluminium	2.8×10^{-8}

Nichrome	1.1×10^{-6} (used in heaters)
Rubber	10^{13} (insulator)

11.7 Resistors in Series and Parallel

Series

- Same current through each.
- Total resistance $R = R_1 + R_2 + R_3$.
- Voltages divide ($V = V_1 + V_2 + V_3$).

Parallel

- Same voltage across each.
- $1/R = 1/R_1 + 1/R_2 + 1/R_3$.
- Current divides ($I = I_1 + I_2 + I_3$).

11.8 Electrical Energy and Power

Power (P) = rate of using energy. $P = V \times I = I^2 R = V^2/R$

Unit: **watt (W)**.

Energy = $P \times t$ Unit of electrical energy: **kilowatt-hour (kWh)** = unit on your electricity bill. 1 kWh = $1000 \text{ W} \times 3600 \text{ s} = 3.6 \times 10^6 \text{ J}$.

11.9 Heating Effect of Current

When current flows through a resistor, electrical energy is converted to heat. $H = I^2 R t$ (Joule's law of heating)

Applications:

- **Electric heater, iron, toaster, geyser, kettle, room heater, hair dryer** — all use high-resistance wire (nichrome).
- **Filament bulb** — tungsten filament glows white hot.
- **Fuse** — low-melting-point wire; melts when too much current flows, breaking the circuit.

The rating of an appliance: e.g., "60 W, 220 V" means it consumes 60 W at 220 V; current = $P/V = 0.27 \text{ A}$.

11.10 Domestic Wiring and Safety

- **Live wire** (red, 220 V), **neutral wire** (black, 0 V), **earth wire** (green, safety).
- **Switch** is always on the **live wire** so that when off, the appliance is at 0 V.
- **Fuse** in series with live wire.
- **Earthing** — connects the metal body of appliance to earth; if live wire touches body, current goes to earth → trips fuse → no shock.

Safety devices

- **Fuse** — wire of low melting point; melts at excess current.
- **MCB** (Miniature Circuit Breaker) — automatic switch that trips on overload.
- **ELCB / RCCB** — trips on small leakage currents, preventing shocks.

11.11 Magnetic Materials and Magnets

Magnet = object that attracts iron, cobalt, nickel; has north and south poles. **Like poles repel, unlike poles attract.**

Types

- **Natural magnet** — magnetite (lodestone), Fe_3O_4 .
- **Artificial magnets** — made by rubbing with magnet, by electric current, by induction.

Types of magnetic materials

- **Ferromagnetic** — strongly attracted (iron, cobalt, nickel). Used to make permanent magnets.
- **Paramagnetic** — weakly attracted (aluminium, platinum).
- **Diamagnetic** — weakly repelled (copper, bismuth, wood).

11.12 Magnetic Field

Region around a magnet where its influence is felt. Represented by **field lines** — from N to S outside the magnet; closed loops.

Properties of field lines:

- Continuous closed curves.
- Never cross.
- Closer lines = stronger field.

Earth's magnetism

- Earth itself behaves like a giant magnet.
- **Magnetic south pole** is near geographic north (because it attracts the north pole of compass needle).

- The angle between true north and magnetic north is the **angle of declination**.

11.13 Electromagnetism

A current-carrying wire produces a magnetic field around it. **Right-hand grip rule** — thumb points in direction of current, fingers curl in direction of magnetic field.

Solenoid

A coil of wire. Behaves like a bar magnet with N and S poles determined by current direction.

Strength of electromagnet increases with:

- More current.
- More turns of wire.
- Soft iron core inside.

Electromagnet applications

- Electric bell, telegraph, telephone receiver.
- Scrap-yard crane (lifts iron cars).
- MRI machine.
- Relay (switch).
- Speaker.

11.14 Force on a Current-Carrying Conductor in a Magnetic Field

Motor effect: A current-carrying wire in a magnetic field experiences a force. **$F = BIL$** (B = magnetic flux density in T, I = current in A, L = length in m).

Direction: **Fleming's Left-Hand Rule** (for motors):

- Thumb Force (motion)
- First finger Field (N to S)
- Second finger Current (conventional, + to -)

11.15 Electromagnetic Induction

Faraday's Law: A changing magnetic field through a coil induces an EMF (and current if circuit is closed). **Direction of induced current** is given by **Lenz's Law** — it opposes the change that caused it (so energy is conserved).

Methods to induce EMF:

- Move magnet into coil.

- Move coil around magnet.
- Change current in nearby coil.

Applications

- **AC generator (alternator)** — coil rotates in magnetic field → produces AC.
- **DC generator / dynamo** — uses split-ring commutator → produces DC.
- **Microphone** — sound waves move a coil in magnetic field → induced current.
- **Transformer** — two coils around iron core; changing current in one induces current in the other.

11.16 Electric Motor (DC)

Converts electrical energy → mechanical energy.

Parts:

- **Armature (coil)** — rotates between magnetic poles.
- **Split-ring commutator** — reverses current direction every half turn → coil keeps rotating in same direction.
- **Brushes** — connect coil to external battery.

Works on **motor effect** ($F = BIL$).

In an **AC motor**, the supply is already alternating, so a plain slip-ring can be used.

11.17 Transformer

Two coils (primary and secondary) wound on a common soft-iron core. Works only with AC (because AC changes → changing magnetic flux).

Equations:

- $V_p / V_s = N_p / N_s$ (turns ratio = voltage ratio)
- $V_p I_p = V_s I_s$ (ideal transformer, 100% efficient)

Step-up transformer — more turns in secondary ($N_s > N_p$) → increases voltage. **Step-down transformer** — fewer turns in secondary → decreases voltage.

Energy losses in real transformers

- Resistance of coils (copper loss) → heat.
- Eddy currents in core → heat. Reduced by **laminated** core.
- Hysteresis loss.
- Flux leakage.

11.18 Domestic Power Supply in Nepal

- AC, 220 V, 50 Hz.
- Step-down transformer near house reduces high-voltage transmission voltage to 220 V.
- Energy meter records kWh.
- Two-pin or three-pin plug (earth pin).

11.19 Common Electrical Devices and Their Ratings

Device	Typical power
LED bulb	7–15 W
Incandescent bulb	40–100 W
Ceiling fan	60–80 W
Television	80–200 W
Refrigerator	100–400 W
Iron	750–1000 W
Water heater	1000–2000 W
Air conditioner	1000–2000 W

Electricity bill = (kWh consumed) × (rate per unit, e.g., Rs 8–12).

Chapter 12 — Universe

12.1 What is the Universe?

The **universe** is everything that exists — all matter, energy, space, and time. It includes all stars, planets, galaxies, and the vast empty space between them.

The universe is **about 13.8 billion years old** and **about 93 billion light-years across**.

12.2 The Solar System

The **solar system** consists of the **Sun** (a star) and all objects bound to it by gravity — 8 planets, dwarf planets, moons, asteroids, comets, meteoroids.

Order of planets from the Sun:

- 1. Mercury
- 2. Venus
- 3. Earth
- 4. Mars
- 5. Jupiter
- 6. Saturn
- 7. Uranus
- 8. Neptune

Mnemonic: My Very Educated Mother Just Served Us Noodles.

The two groups

Inner / Terrestrial planets (rocky, small): Mercury, Venus, Earth, Mars. **Outer / Gas giants** (large, gaseous): Jupiter, Saturn, Uranus, Neptune.

Asteroid belt between Mars and Jupiter.

Key data

Planet	Distance from Sun (million km)	Period (Earth years)	Notable
Mercury	58	0.24	Closest to sun, no atmosphere, very hot days / cold nights
Venus	108	0.62	Hottest planet (CO ₂ greenhouse), brightest in sky
Earth	150	1.00	Only planet with life, 71% water
Mars	228	1.88	Red planet (iron oxide), has 2 moons
Jupiter	778	11.86	Largest, has Great Red Spot (storm), 79+ moons
Saturn	1427	29.46	Famous rings (ice + rock), 82+ moons
Uranus	2870	84	Tilted on side, blue-green (methane)
Neptune	4497	164.8	Strongest winds, deep blue, 14 moons

Pluto

Reclassified as a **dwarf planet** by the IAU in 2006. Other dwarf planets: Ceres, Eris, Makemake, Haumea.

12.3 The Sun

- A star at the centre of the solar system.
- Composition: ~73% hydrogen, ~25% helium, 2% other.
- Energy source: **nuclear fusion** — $4\text{ H nuclei} \rightarrow 1\text{ He nucleus} + \text{energy}$.
 - $4\text{ }^1\text{H} \rightarrow \text{}^4\text{He} + 2\text{e}^+ + 2\nu + 2\gamma + 26.7\text{ MeV energy}$.
- Surface temperature ~5,500 °C; core ~15 million °C.
- Light reaches Earth in ~8 minutes 20 seconds.
- Will run out of hydrogen in about 5 billion years → become a red giant → then a white dwarf.

12.4 The Earth

- Third planet from the Sun.
- Diameter ~12,742 km.
- **71% covered by water.**
- Has one natural satellite — **the Moon** (diameter ~3,474 km, distance ~384,400 km).
- Takes 365.25 days to orbit the sun, 24 hours to rotate on its axis.
- Axis tilted 23.5° → causes **seasons**.

12.5 The Moon

- Earth's only natural satellite.
- No atmosphere, no water.
- Goes through **phases** — new moon → waxing crescent → first quarter → waxing gibbous → full moon → waning gibbous → last quarter → waning crescent.
- **Lunar eclipse** — Earth between sun and moon; Earth's shadow falls on moon. Happens at full moon.
- **Solar eclipse** — Moon between sun and earth; moon's shadow falls on Earth. Happens at new moon.
- Tides caused by Moon's and Sun's gravity on Earth's oceans.

12.6 Stars

A **star** is a self-luminous ball of hot gas that produces energy by nuclear fusion.

- Stars have different colours depending on temperature:
 - Blue — hottest (~30,000 K).
 - White — ~10,000 K (like Sirius).
 - Yellow — ~6,000 K (like Sun).
 - Red — coolest (~3,000 K, like Betelgeuse).

Life cycle of a star

Massive star:

Nebula (gas cloud)

Protostar

Main-sequence star (like Sun)

Red giant

Planetary nebula

White dwarf

(slowly cools to) Black dwarf

Very massive star:

Supergiant

Supernova (huge explosion)

Neutron star or Black hole

12.7 Constellations

A **constellation** is a pattern of stars as seen from Earth. There are **88 official constellations**.

Examples: **Ursa Major (Saptarishi), Orion, Cassiopeia, Scorpius**.

Ursa Major is famous in Nepal; the two pointer stars (Dubhe and Merak) point to **Polaris (Dhruva tara)**, the Pole Star — almost stationary in the north.

12.8 Galaxy

A **galaxy** is a huge collection of stars, gas, dust, planets, and dark matter, bound by gravity.

Our galaxy is the **Milky Way** — a **spiral galaxy** with ~200 billion stars. The Sun is in one of its spiral arms, about 26,000 light-years from the centre.

Types of galaxies:

- **Spiral** (like Milky Way, Andromeda).
- **Elliptical**.
- **Irregular** (like Magellanic Clouds).

Andromeda — nearest large galaxy (2.5 million light-years away). Will eventually merge with Milky Way.

12.9 Astronomical Distances

Because the universe is so vast, normal units (km) are too small. Astronomers use:

- **Astronomical Unit (AU)** = average Earth–Sun distance = 150 million km.
- **Light year (ly)** = distance light travels in 1 year = 9.46×10^{12} km.
- **Parsec (pc)** = $3.26 \text{ ly} \approx 3.09 \times 10^{13} \text{ km}$.

12.10 Theories of the Origin of the Universe

- **Big Bang Theory** (most accepted) — universe began ~13.8 billion years ago from a hot, dense point; has been expanding and cooling ever since. Evidence: cosmic microwave background radiation, redshift of galaxies.
- **Steady State Theory** — universe has no beginning or end; new matter is continuously created. (Now mostly discredited.)
- **Pulsating Theory** — universe expands then contracts in cycles.

12.11 Space Exploration

- First artificial satellite: **Sputnik 1** (USSR, 1957).
- First human in space: **Yuri Gagarin** (USSR, 1961).
- First human on the Moon: **Neil Armstrong** (USA, Apollo 11, 1969).
- First space station: **Salyut 1** (USSR, 1971). Current: **ISS** (international).
- Mars rovers — Curiosity, Perseverance.
- Indian space agency **ISRO** — Chandrayaan (Moon), Mangalyaan (Mars).
- **Nepali satellite** — NepaliSat-1 launched in 2019.

12.12 Light Pollution and Astronomy

Excess artificial light at night makes stars invisible from cities. Solutions: shielded lights, low-light areas for observatories.

Chapter 13 — Information and Communication Technology (ICT)

13.1 What is ICT?

ICT = Information and Communication Technology — the tools and systems used to **create, store, retrieve, transmit, and manipulate** information.

It includes computers, mobile phones, internet, satellite, radio, TV, and all related software.

13.2 Computer — A Brief Overview

A computer is an electronic device that processes data according to a program.

Basic parts

- **Hardware** — physical parts (CPU, monitor, keyboard, etc.).
- **Software** — programs that tell hardware what to do.

13.3 Computer Hardware

Part	Function
CPU (Central Processing Unit)	Brain of computer; executes instructions. Has ALU (Arithmetic Logic Unit) and CU (Control Unit).
Memory (RAM, ROM)	Temporary storage (RAM) or permanent (ROM).
Hard disk / SSD	Long-term storage of data and programs.
Motherboard	Connects all parts.
Monitor	Output — shows output visually.
Keyboard, mouse	Input devices.
Printer	Output — paper copy.
Speakers	Output — sound.
Microphone	Input — sound.

Input / Output / Storage

Input devices: keyboard, mouse, scanner, joystick, microphone, touchpad, barcode reader, digital camera. **Output devices:** monitor, printer, speaker, plotter, projector. **Storage devices:** hard disk, SSD, USB flash drive, CD/DVD, memory card, magnetic tape.

Memory units (powers of 2 mostly)

8 bits = 1 byte 1024 bytes = 1 KB (kilobyte) 1024 KB = 1 MB (megabyte) 1024 MB = 1 GB (gigabyte)
1024 GB = 1 TB (terabyte) 1024 TB = 1 PB (petabyte)

13.4 Software

System software

- **Operating system** (Windows, macOS, Linux, Android, iOS) — manages hardware, provides interface.
- **Device drivers** — let OS talk to hardware.
- **Utility programs** — antivirus, disk cleanup, file manager.

Application software

- **General purpose** — MS Office, browsers, media players.
- **Specific purpose** — accounting software, school management, hospital systems.

Programming languages

- High-level: Python, Java, C++, JavaScript, C#.
- Low-level: Assembly, Machine code.
- Used to write software.

13.5 Data and Information

- **Data** — raw facts and figures.
- **Information** — processed data that is meaningful.

Example: "23, 25, 27, 30" data. "Average temperature of Kathmandu in July is 26 °C" information.

13.6 Number System in Computing

Computers work in **binary (base 2)** — only 0 and 1.

- **Decimal (10)** base-10 (0–9).
- **Binary (2)** base-2 (0,1).
- **Octal (8)** 0–7.
- **Hexadecimal (16)** 0–9, A–F.

Binary digit = **bit**. 8 bits = 1 byte.

ASCII and Unicode represent characters as numbers.

13.7 The Internet

The **internet** is a global network of interconnected computers that communicate using standard protocols (mainly **TCP/IP**).

Services on the internet:

- **WWW (World Wide Web)** — pages viewed in browsers.
- **Email** — electronic mail.
- **Social media** — Facebook, Twitter/X, Instagram, TikTok.
- **Search engines** — Google, Bing.
- **Cloud storage** — Google Drive, Dropbox.
- **Streaming** — YouTube, Netflix.
- **Online learning** — Khan Academy, Coursera.
- **E-commerce** — Daraz, Amazon.

- **Video conferencing** — Zoom, Google Meet.

World Wide Web vs Internet

- **Internet** is the network infrastructure.
- **WWW** is a service running on the internet that uses HTTP and HTML.

13.8 Computer Network

Two or more computers connected to share resources.

Types by area

- **PAN** (Personal Area Network) — within a few metres (Bluetooth).
- **LAN** (Local Area Network) — within a building (school, office).
- **MAN** (Metropolitan Area Network) — within a city.
- **WAN** (Wide Area Network) — across countries/continents (the internet).

Topology

- **Bus, Star, Ring, Mesh, Tree, Hybrid.**

Wired media

- **Twisted pair cable (Ethernet).**
- **Coaxial cable.**
- **Fibre optic cable** — fastest, uses light; immune to electrical noise.

Wireless media

- **Wi-Fi** (radio waves).
- **Bluetooth** (short range).
- **Microwave** (line of sight).
- **Satellite** (long range).
- **Infrared** (very short, line of sight).

13.9 Mobile Communication

- Mobile phones use **cellular networks**.
- Each cell has a **base transceiver station (BTS)**.
- Phone connects to nearest BTS network destination.
- Generations: **1G** (analog voice) **2G** (GSM, SMS) **3G** (internet) **4G** (fast data, video) **5G** (ultra fast, IoT).

- **SIM card** identifies subscriber.

Smartphone features

- Touchscreen, camera, GPS, apps, internet, biometrics.

13.10 Social Media

Platforms where users create and share content.

- Examples: Facebook, Instagram, X (Twitter), TikTok, YouTube, WhatsApp, LinkedIn.

Positive uses

- Connect with friends, family.
- Share knowledge, news.
- Marketing, business.
- Awareness, activism.
- Education, online classes.

Negative aspects

- Cyberbullying.
- Fake news, misinformation.
- Addiction, mental health issues.
- Privacy loss, data theft.
- Wasted time.

13.11 Cyber Safety and Security

- Use **strong passwords** (mix of letters, numbers, symbols).
- **Two-factor authentication.**
- Don't share personal info online.
- Be careful with emails from unknown senders (**phishing**).
- Install **antivirus** software and keep it updated.
- Don't click unknown links or download suspicious files.
- Use HTTPS sites.
- Backup important data regularly.
- Log out from public computers.

Cybercrime laws in Nepal — Electronic Transactions Act (ETA) 2063 and its amendments; Cyber Security Act 2025.

13.12 ICT in Nepal

- **Nepal Telecom (NTC)** and **Ncell** are the main mobile operators.
- Internet users: ~80%+ of population (2024).
- **Nepal Government's** digital initiatives: Digital Nepal Framework, e-Governance, online services.
- Online education became essential during COVID-19.
- Challenges: digital divide (rural vs urban), electricity, infrastructure, cyber security.

13.13 ICT and Society

- Has revolutionised communication, business, education, healthcare, entertainment.
- Job creation in software, BPO, e-commerce.
- Reduced distance; brought information to fingertips.
- Has also brought new problems (job loss in some sectors, addiction, surveillance).

13.14 Future Technologies (brief)

- **Artificial Intelligence (AI)** — machines that learn.
- **Machine Learning** — subset of AI.
- **Internet of Things (IoT)** — everyday objects connected to internet.
- **Big Data** — analysing huge datasets.
- **Blockchain** — secure, decentralised ledgers.
- **Cloud Computing** — computing over the internet.
- **Virtual Reality (VR) / Augmented Reality (AR).**
- **Robotics** — autonomous machines.

Chapter 14 — Classification of Elements

14.1 Elements, Compounds and Mixtures

	Element	Compound	Mixture
Definition	Pure substance made of one type of atom	Pure substance made of two or more elements chemically combined	Two or more substances physically mixed
Composition	Fixed (one element)	Fixed ratio by mass	Variable
Separation by physical means	Not possible	Not possible	Possible

Examples	O ₂ , Fe, Au	H ₂ O, NaCl, CO ₂	Air, sea water, soil
----------	-------------------------	---	----------------------

14.2 Discovery of Elements and the Need for Classification

By the 19th century, many elements had been discovered. Scientists looked for patterns among them.

Johann Döbereiner (1817) — Triads: groups of three elements with similar properties and the middle one's atomic weight $\approx$ average of the other two (Cl, Br, I; Li, Na, K).

John Newlands (1866) — Law of Octaves: when elements arranged by atomic mass, every 8th element has similar properties (like musical octaves).

Dmitri Mendeleev (1869) — Periodic Law: properties of elements are a periodic function of their atomic weights. Published the first widely-accepted periodic table.

Henry Moseley (1913) — modern periodic law based on **atomic number**.

14.3 Modern Periodic Law

The physical and chemical properties of elements are a periodic function of their **atomic number (Z)**.

14.4 Structure of the Modern Periodic Table

- **Periods** — horizontal rows (7 periods).
- **Groups** — vertical columns (18 groups).
- **Period number** = number of the highest main shell with electrons.
- **Group number** (1, 2, 13–18) tells about valence electrons.

Four blocks

- **s-block** — Groups 1, 2 (left).
- **p-block** — Groups 13–18 (right).
- **d-block** — Groups 3–12 (transition metals, middle).
- **f-block** — Lanthanoids and Actinoids (placed separately at bottom).

14.5 Classification of Elements into s, p, d, f Blocks

Block	Elements	Valence orbital
s	H, He, Li, Be, Na, Mg, K, Ca, ...	$ns^1\ 2$
p	B-Ne, Al-Ar, Ga-Kr, In-Xe, Tl-Rn	$ns^2np^1\ 6$

d	Sc-Zn, Y-Cd, La, Hf-Hg, Ac	$(n-1)d^{1-10} ns^2$
f	Ce-Lu (lanthanoids), Th-Lr (actinoids)	$(n-2)f^{1-14} (n-1)d^1 ns^2$

14.6 Metals, Non-metals and Metalloids

Metals (left + middle of table)

- Shiny, malleable, ductile, good conductors of heat and electricity, sonorous, high melting point, form cations (+ ions), form basic oxides.
- Examples: Na, Mg, Fe, Cu, Au.

Non-metals (right of table)

- Dull, brittle (if solid), poor conductors, form anions (– ions), form acidic oxides.
- Examples: O, S, Cl, N.

Metalloids (borderline)

- Have properties of both.
- Examples: B, Si, Ge, As, Sb, Te.

14.7 Periodic Trends

As you go **across a period (left → right)**:

- Atomic radius **decreases** (more nuclear charge pulls electrons closer).
- Ionisation energy **increases** (harder to remove electron).
- Electronegativity **increases**.
- Metallic character **decreases**.
- Non-metallic character **increases**.

As you go **down a group (top → bottom)**:

- Atomic radius **increases** (more shells).
- Ionisation energy **decreases** (outer electron farther from nucleus).
- Electronegativity **decreases**.
- Metallic character **increases**.
- Non-metallic character **decreases**.

Definition refresher

- **Atomic radius** — distance from nucleus to outermost electron.
- **Ionisation energy** — energy required to remove the outermost electron from a gaseous atom.

- **Electronegativity** — tendency of an atom to attract shared electrons in a bond.
- **Electron affinity** — energy change when an electron is added to a gaseous atom.

14.8 Group-wise Important Families

Group 1 — Alkali metals (Li, Na, K, Rb, Cs, Fr)

- 1 valence electron, very reactive, soft, stored in oil (react with air/water), form +1 ions, react with water to give hydroxide + H₂.
- Reactivity increases down the group.

Group 2 — Alkaline earth metals (Be, Mg, Ca, Sr, Ba, Ra)

- 2 valence electrons, form +2 ions, less reactive than Group 1, form basic oxides (e.g., CaO, MgO).

Group 17 — Halogens (F, Cl, Br, I, At)

- 7 valence electrons, very reactive non-metals, form -1 ions, diatomic molecules (F₂, Cl₂, ...).
- Reactivity decreases down the group.

Group 18 — Noble gases (He, Ne, Ar, Kr, Xe, Rn)

- 8 valence electrons (2 for He), very stable, almost inert, monatomic gases, used in lighting (Ne), welding (Ar), balloons (He).

14.9 Periodicity in Properties of Selected Elements

Period 2 elements: Li, Be, B, C, N, O, F, Ne

Property	Li	Be	B	C	N	O	F	Ne
Atomic radius	largest							smallest
Metallic	strong	metal	metalloid	non-metal	non-metal	non-metal	halogen	noble gas
Oxide	Li ₂ O (basic)	BeO (amphoteric)	B ₂ O ₃ (acidic)	CO ₂ (acidic)	N ₂ O ₅ (acidic)	—	OF ₂	—

Period 3: similar trend: Na (metal) Mg Al Si P S Cl Ar.

14.10 Diagonal Relationship

Some pairs of elements diagonally adjacent show similar properties:

- Li and Mg (form nitrides, carbonates, phosphates).
- Be and Al (amphoteric oxides and hydroxides).

Reason: similar charge/size ratio.

14.11 Uses of Periodic Table

- Predicts properties of new / undiscovered elements.
- Predicts formula of compounds.
- Helps design materials with desired properties.
- Foundation for inorganic and organic chemistry.

Chapter 15 — Chemical Reaction

15.1 What is a Chemical Reaction?

A **chemical reaction** is a process in which one or more substances (**reactants**) are converted into new substances (**products**) with different properties.

Evidence of a chemical reaction:

- Change in colour.
- Evolution of gas (bubbles).
- Formation of precipitate.
- Change in temperature (heat released or absorbed).
- Change in smell.

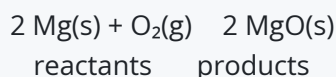
Example: Iron + Sulphur → Iron sulphide (FeS)

- Greyish iron + yellow sulphur → black FeS. New substance with different properties.

15.2 Chemical Equations

A **chemical equation** is a shorthand description of a chemical reaction using symbols and formulae.

Parts of an equation



Balancing equations

A balanced equation has equal number of atoms of each element on both sides, satisfying the **law of conservation of mass**.

Example: $\text{Fe} + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$ (not balanced) **Balanced:** $4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3$ (4 Fe, 6 O on each side.)

Steps to balance

1. Write unbalanced equation.
2. Count atoms of each element on both sides.
3. Add coefficients (never change subscripts).
4. Balance one element at a time; often balance H and O last.
5. Check final balance.

15.3 Types of Chemical Reactions

1. Combination (Synthesis)

Two or more reactants combine to form one product. $A + B \rightarrow AB$

- $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$
- $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

2. Decomposition

One reactant breaks into simpler products. $AB \rightarrow A + B$

- $2 \text{FeSO}_4 \rightarrow \text{Fe}_2\text{O}_3 + \text{SO}_2 + \text{SO}_3$ (heat)
- $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ (heat)
- $2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2$ (MnO_2 catalyst)

3. Single Displacement (Replacement)

A more reactive element displaces a less reactive one. $A + BC \rightarrow AC + B$

- $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$
- $\text{Fe} + \text{CuSO}_4 \rightarrow \text{FeSO}_4 + \text{Cu}$

4. Double Displacement (Metathesis)

Exchange of ions between two compounds. $AB + CD \rightarrow AD + CB$

- $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow \text{BaSO}_4 + 2 \text{NaCl}$
- $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

5. Redox (Oxidation–Reduction)

Both oxidation and reduction happen together.

- Oxidation = loss of electrons (gain of oxygen or loss of hydrogen).
- Reduction = gain of electrons (loss of oxygen or gain of hydrogen).

Mnemonic: "OIL RIG" — **O**xidation **I**s **L**oss (of electrons); **R**eduction **I**s **G**ain.

Or "OILCAR" — Oxidation Is Loss, Cathode is Reduction (in electrochemistry).

Example: $2 \text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$ (Mg is oxidised, O_2 is reduced).

6. Exothermic vs Endothermic

- **Exothermic** — releases heat (combustion, neutralisation, respiration). Temperature rises.
- **Endothermic** — absorbs heat (photosynthesis, dissolving NH_4Cl in water, thermal decomposition). Temperature drops.

15.4 Energy Changes in Chemical Reactions

Every chemical reaction involves a change in energy. Bonds break (energy in) and new bonds form (energy out).

- If energy released > energy absorbed **exothermic** (e.g., combustion).
- If energy absorbed > energy released **endothermic** (e.g., photosynthesis).

Activation energy = minimum energy needed to start the reaction (often a little push like a spark).

15.5 Factors Affecting Rate of Reaction

Factor	Effect on rate
Concentration of reactants	Higher concentration faster rate (more collisions)
Temperature	Higher temp faster rate (more energetic collisions)
Surface area	More finely divided faster rate (more contact)
Catalyst	Speeds up reaction without being consumed
Pressure (for gases)	Higher pressure faster rate (more collisions)

Collision theory: reactions occur when reactant particles **collide with sufficient energy ($\geq$ activation energy) and correct orientation**.

15.6 Catalysts

A **catalyst** is a substance that increases the rate of a reaction without being consumed.

- **Positive catalyst** — speeds up (most common).
- **Negative catalyst (inhibitor)** — slows down.
- **Enzymes** are biological catalysts.

Examples: MnO_2 in decomposition of H_2O_2 ; Pt in Ostwald process; Fe in Haber process; enzymes in digestion.

15.7 Reversible and Irreversible Reactions

- **Irreversible** — proceeds to completion; products cannot recombine to form reactants. (e.g., burning, rusting.)
- **Reversible** — sign; products can react to give back reactants. (e.g., $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$; heating $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} \rightleftharpoons \text{CuSO}_4 + 5\text{H}_2\text{O}$)

15.8 Oxidation and Reduction in Daily Life

- **Corrosion / rusting** — iron + O_2 + $\text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ (rust). Slow oxidation. Prevented by painting, oiling, galvanising (Zn coating).
- **Rancidity** — fats and oils oxidise, smell bad. Prevented by antioxidants, airtight containers, refrigeration.
- **Burning of fuels** — combustion of methane, LPG, petrol — all redox reactions.

15.9 Acids, Bases and Salts — Quick Overview

Acids

- Sour taste, turn blue litmus red.
- Release H^+ in water.
- Examples: HCl, H_2SO_4 , HNO_3 , CH_3COOH (acetic acid in vinegar), citric acid (lemon), lactic acid (curd), ascorbic acid (vitamin C).

Bases

- Bitter, soapy feel, turn red litmus blue.
- Release OH^- in water.
- Examples: NaOH (caustic soda), KOH, NH_4OH .
- **Alkalis** — bases soluble in water.

Indicators

- **Litmus** (red in acid, blue in base).
- **Methyl orange** (red in acid, yellow in base).
- **Phenolphthalein** (colourless in acid, pink in base).

- **Universal indicator / pH paper** — gives full range 1–14.
- **Natural indicators** — turmeric (yellow → red with base), red cabbage juice (red with acid, green/yellow with base).

pH Scale

0 (very acidic) → 7 (neutral) → 14 (very basic/alkaline).

- Acidic: $\text{pH} < 7$.
- Neutral: $\text{pH} = 7$.
- Basic: $\text{pH} > 7$.

Reactions of acids

- **Acid + Metal** → Salt + Hydrogen gas (for metals above H in reactivity series).
 - $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
- **Acid + Base** → Salt + Water (**neutralisation**).
 - $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
- **Acid + Metal carbonate** → Salt + Water + CO_2 .
 - $2\text{HCl} + \text{CaCO}_3 \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
- **Acid + Metal oxide** → Salt + Water.
 - $2\text{HCl} + \text{CuO} \rightarrow \text{CuCl}_2 + \text{H}_2\text{O}$

Importance of pH in daily life

- Acidic soil → bad for crops; treated with lime (CaO/CaCO_3) or wood ash.
- Stomach acid (HCl) → digestion; antacids (milk of magnesia) neutralise it.
- Acid rain → damages buildings, kills aquatic life.
- Our skin and hair have a slightly acidic pH → soap (basic) can disrupt it.

Salts

Salts are ionic compounds formed from the cation of a base and anion of an acid.

- Common salt = NaCl .
- Washing soda = $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.
- Baking soda = NaHCO_3 (used in baking, antacid).
- Plaster of Paris = $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ (used for casts).

Chapter 16 — Gases

16.1 Properties of Gases

- No fixed shape or volume — take the shape and volume of the container.
- Highly compressible (large empty spaces between particles).
- Low density compared to liquids and solids.
- Mix evenly and completely in all proportions (diffuse).
- Exert pressure on walls of container (due to collisions of gas molecules).
- Expand indefinitely when heated.

Kinetic Theory of Gases — assumptions:

- Gas made of tiny particles in constant random motion.
- Volume of particles negligible compared to container.
- No intermolecular forces (ideal gas assumption).
- All collisions are perfectly elastic (no energy loss).
- Average kinetic energy ∝ absolute temperature.

16.2 Gas Laws — The Big Three

Boyle's Law (1662)

At constant temperature, the volume of a given mass of gas is **inversely proportional** to its pressure. $P \times V = \text{constant}$ or $P_1V_1 = P_2V_2$

So if pressure doubles, volume halves. Application: breathing (diaphragm contracts → lung volume ↓ → pressure ↑ → air rushes in).

Charles's Law (1787)

At constant pressure, the volume of a given mass of gas is **directly proportional** to its absolute temperature (in Kelvin). $V / T = \text{constant}$ or $V_1 / T_1 = V_2 / T_2$

So heating a gas at constant pressure makes it expand. Application: hot-air balloon.

Avogadro's Law (1811)

At constant temperature and pressure, the volume of a gas is **directly proportional** to the number of moles of gas. $V / n = \text{constant}$

So equal volumes of gases at the same T and P contain equal numbers of molecules. Application: explains why 1 mole of any gas at STP occupies 22.4 L.

16.3 Combined Gas Law

Combining Boyle's and Charles's laws: $P_1V_1 / T_1 = P_2V_2 / T_2$

16.4 Ideal Gas Equation

$$P \times V = n \times R \times T$$

where P = pressure, V = volume, n = number of moles, R = universal gas constant = $8.314 \text{ J}/(\text{mol}\cdot\text{K})$, T = temperature in Kelvin.

One mole of ideal gas at STP (273 K, 1 atm = 101,325 Pa) occupies **22.4 L** (molar volume).

16.5 Dalton's Law of Partial Pressures

The total pressure of a mixture of non-reacting gases equals the sum of the partial pressures of the individual gases. **$P_{\text{total}} = P_1 + P_2 + P_3 + \dots$**

Application: explains oxygen partial pressure in air; breathing at high altitude; gas collection over water.

16.6 Graham's Law of Diffusion

The rate of diffusion of a gas is **inversely proportional** to the square root of its molar mass. **$r_1 / r_2 = \sqrt{M_2 / M_1}$**

So lighter gases diffuse faster. Example: H_2 escapes faster than O_2 ; NH_3 (17) reaches nose faster than HCl (36.5) when cotton swabs are placed at the two ends of a long tube.

16.7 Gas Constant (R) and STP

- **STP** (Standard Temperature and Pressure): 273.15 K, 1 atm.
- **SATP** (Standard Ambient Temperature and Pressure): 298 K, 1 atm.
- $R = 0.0821 \text{ L}\cdot\text{atm}/(\text{mol}\cdot\text{K}) = 8.314 \text{ J}/(\text{mol}\cdot\text{K})$.

16.8 Numerical Examples

Q1. A gas at 300 K occupies 2 L at 1 atm. What volume at 600 K (same pressure)? $V_1/T_1 = V_2/T_2$ $2/300 = V_2/600$ $V_2 = \mathbf{4 \text{ L}}$.

Q2. 4 L of gas at 2 atm is compressed to 2 L. New pressure (T constant)? $P_1V_1 = P_2V_2$ $2 \times 4 = P_2 \times 2$
 $P_2 = \mathbf{4 \text{ atm}}$.

Q3. 0.5 mol of gas at 27 °C occupies what volume at 1 atm? $T = 300 \text{ K}$. $V = nRT/P = 0.5 \times 0.0821 \times 300 / 1 = \mathbf{12.3 \text{ L}}$.

16.9 Real Gases vs Ideal Gases

- **Ideal gas** — strictly follows gas laws; particles have no volume, no attraction.

- **Real gases** — particles have volume and weak attractions; deviate from ideal behaviour, especially at **high pressure** and **low temperature**.
- At very high P particles forced close repulsions matter.
- At very low T particles slow attractions matter may condense to liquid.

16.10 Liquefaction of Gases

When cooled enough and compressed, a gas becomes a liquid. Example:

- LPG (liquefied petroleum gas) — propane + butane, used as cooking fuel.
- LNG (liquefied natural gas) — methane, cooled to $-162\text{ }^{\circ}\text{C}$ for transport.
- LOX (liquid oxygen) — used as oxidiser in rockets.
- Liquid nitrogen ($-196\text{ }^{\circ}\text{C}$) — used in cryogenics, freezing food, removing warts.

16.11 Applications of Gas Laws

- **Bicycle pump** — pushing piston compresses air (Boyle).
- **Soda bottle** — CO_2 dissolved under pressure; opens pressure drops CO_2 comes out as bubbles.
- **Weather balloon** — rises into atmosphere pressure drops volume expands.
- **Hot-air balloon** — heat air Charles's law volume increases some air escapes balloon rises.
- **Breathing** — diaphragm changes lung volume pressure changes air flows.
- **Syringe** — pulling plunger increases volume decreases pressure fluid flows in.
- **Pressure cooker** — trapped steam raises pressure raises boiling point food cooks faster.

Chapter 17 — Metal and Non-metals

17.1 Properties of Metals (recap and expand)

Physical properties

- **Solid** at room temperature (except mercury, which is liquid).
- **Lustrous** (shiny) when freshly cut.
- **Malleable** — can be hammered into thin sheets.
- **Ductile** — can be drawn into wires.
- **Good conductors** of heat and electricity.
- **Sonorous** — produce ringing sound when struck (used in bells).
- **High melting and boiling points** (exceptions: Hg, Ga, Cs).

- **High density** (alkali metals are exceptions — they float on water!).

Chemical properties

- Lose valence electrons easily → form **cations** (+ ions). e.g., $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$.
- React with oxygen to form basic oxides (e.g., MgO , Na_2O).
- React with water to release H_2 (Na, K react vigorously; Mg slowly; Fe, Cu do not react with cold water).
- React with acids to release H_2 (for metals above hydrogen in reactivity series).
- React with non-metals to form salts (e.g., NaCl).

17.2 Properties of Non-metals

Physical

- Solid, liquid, or gas at room temperature (S solid, Br liquid, O gas).
- **Dull** (not shiny), brittle if solid.
- **Poor conductors** of heat and electricity (graphite, an allotrope of carbon, is a conductor).
- Low density, low melting points.
- Not sonorous.

Chemical

- Gain electrons → form **anions** (– ions). e.g., $\text{Cl} + \text{e}^- \rightarrow \text{Cl}^-$.
- React with oxygen to form acidic oxides (e.g., SO_3 , CO_2).
- Do not react with water or dilute acids (generally).
- React with metals to form salts.

17.3 Reactivity Series (from most to least reactive)

Metal	Symbol	Notes
Potassium	K	Stored in oil; reacts with cold water
Sodium	Na	Stored in oil; reacts with cold water
Calcium	Ca	Reacts slowly with cold water
Magnesium	Mg	Reacts with hot water/steam
Aluminium	Al	Reacts with steam; protective oxide layer
Zinc	Zn	Reacts with steam/acid
Iron	Fe	Reacts with steam/acid

Lead	Pb	Reacts with acid
Hydrogen	H	(reference, not a metal)
Copper	Cu	No reaction with acid; reacts with conc. HNO_3
Mercury	Hg	No reaction with dilute acids
Silver	Ag	No reaction with dilute acids
Gold	Au	No reaction with most acids (only aqua regia)

Mnemonic: *Please Stop Calling Me A Zebra, I Think He Calls Bull Shit* — Potassium, Sodium, Calcium, Magnesium, Aluminium, Zinc, Iron, Tin, Hydrogen, Copper, ... Silver, Gold.

Importance of reactivity series

- A more reactive metal displaces a less reactive metal from its salt solution.
- $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$ (zinc more reactive than copper).
- $\text{Fe} + \text{CuSO}_4 \rightarrow \text{FeSO}_4 + \text{Cu}$.

17.4 Reaction of Metals with Water

Metal	Reaction
K, Na	Violent; catch fire; produce H_2 and strong base. $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
Ca	Slowly; forms $\text{Ca(OH)}_2 + \text{H}_2$. $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$
Mg	Reacts with steam (not cold water). $\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2 + \text{H}_2$
Al	Reacts with steam
Zn, Fe	React with steam
Cu, Ag, Au	No reaction with water

17.5 Reaction of Metals with Dilute Acids

Metal	HCl / H_2SO_4	HNO_3 (dilute)
Zn, Mg, Fe	Metal + Acid → Salt + H_2	— (HNO_3 doesn't give H_2)
Cu, Ag, Au	No reaction	No reaction with dilute

HNO_3 is an oxidising acid → produces water, NO, NO_2 instead of H_2 .

17.6 Extraction of Metals

The method depends on the metal's reactivity.

Top of the series (K, Na, Ca, Mg, Al) — electrolytic reduction

- Electrolysis of molten ore.
- Example: Aluminium extracted from purified **alumina (Al_2O_3)** by **Hall-Hérout process** (electrolysis in molten cryolite Na_3AlF_6 at $\sim 950^\circ\text{C}$).
- Sodium extracted by electrolysis of molten NaCl (Down's process).

Middle of the series (Zn, Fe, Sn, Pb) — reduction with carbon

- Metal oxide + Carbon (or CO) → Metal + CO_2 .
- Example: $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$.

Bottom of the series (Cu, Hg, Ag, Au) — found native or easily obtained by heating

- Gold, silver, platinum found in pure form in nature.

Steps in metal extraction

1. **Mining** of ore (the mineral from which metal is extracted).
2. **Concentration of ore** — removing sand, soil, etc.
3. **Conversion to oxide** — by roasting (sulphide ores) or calcination (carbonate ores).
4. **Reduction** — to get the metal.
5. **Refining** — purification of the metal.

Important ores

Metal	Ore	Formula
Iron	Haematite	Fe_2O_3
Aluminium	Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Copper	Copper pyrite	CuFeS_2
Zinc	Zinc blende	ZnS
Tin	Cassiterite	SnO_2
Lead	Galena	PbS

17.7 Corrosion

Corrosion is the gradual destruction of metals by chemical reaction with surroundings.

Rusting of iron — $\text{Fe} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ (hydrated iron(III) oxide = rust).

- Requires both **air** and **water**.
- Brown, flaky, weakens the metal.

Prevention

- **Painting, oiling, greasing** — coat surface.
- **Galvanisation** — coat with zinc (sacrificial protection).
- **Chromium plating** — shiny, corrosion-resistant.
- **Tinning** — coat with tin (food cans).
- **Alloying** — mix with other metal.
- **Cathodic protection** — connect to a more reactive metal (Mg, Zn) which corrodes instead.

17.8 Alloys

An **alloy** is a homogeneous mixture of two or more metals (or a metal and a non-metal).

Alloy	Composition	Use
Brass	Cu + Zn	Utensils, decorative
Bronze	Cu + Sn	Statues, medals
Steel	Fe + C (and Cr/Ni)	Construction, tools, vehicles
Stainless steel	Fe + Cr + Ni + C	Cutlery, surgical instruments
Solder	Pb + Sn	Joining metal pieces
Duralumin	Al + Cu + Mg + Mn	Aircraft bodies
Cupronickel	Cu + Ni	Coins

Alloys are usually **stronger** than pure metals because the different-sized atoms prevent layers of atoms from sliding easily.

17.9 Amphoteric Oxides and Hydroxides

Some metal oxides/hydroxides react with both acids and bases — they are **amphoteric**.

Examples:

- $\text{Al}_2\text{O}_3 + 6 \text{HCl} \rightarrow 2 \text{AlCl}_3 + 3 \text{H}_2\text{O}$ (with acid)
- $\text{Al}_2\text{O}_3 + 2 \text{NaOH} \rightarrow 2 \text{NaAlO}_2 + \text{H}_2\text{O}$ (with base)
- ZnO, PbO, SnO are also amphoteric.

17.10 Uses of Metals and Non-metals

Metals: Iron (construction, vehicles), Aluminium (aircraft, foil, wires), Copper (wires, pipes), Gold (jewellery, electronics), Silver (jewellery, mirrors), Mercury (thermometers, barometers).

Non-metals:

- **Oxygen** — respiration, combustion, welding.
 - **Nitrogen** — fertilisers, preservation (food packaging), liquid nitrogen (cryogenics).
 - **Sulphur** — sulphuric acid, gunpowder, rubber vulcanisation.
 - **Phosphorus** — fertilisers, matches.
 - **Chlorine** — water purification, PVC plastic, disinfectants.
 - **Iodine** — antiseptic, thyroid hormone.
 - **Carbon** — fuel (diamond drilling), graphite (pencils, electrodes, lubricants).
-

Chapter 18 — Hydrocarbon and its Compounds

18.1 Introduction to Organic Chemistry

Organic chemistry is the chemistry of **carbon compounds** (except a few simple ones like CO₂, CO, carbonates, cyanides).

Carbon is special because:

- It forms **4 covalent bonds** (tetravalent).
- It forms strong **C-C bonds** — long chains and rings.
- It bonds with H, O, N, S, halogens — millions of compounds.

18.2 Hydrocarbons

Compounds made of **only carbon and hydrogen**.

Saturated hydrocarbons — Alkanes

- All **single bonds**.
- General formula: **C_nH_{2n+2}**
- End with **-ane**.
- Sp³ hybridisation, tetrahedral geometry, 109.5° bond angle.

n	Formula	Name
1	CH ₄	Methane

2	C ₂ H ₆	Ethane
3	C ₃ H ₈	Propane
4	C ₄ H ₁₀	Butane
5	C ₅ H ₁₂	Pentane
6	C ₆ H ₁₄	Hexane

Methane is the main component of **biogas** and **natural gas**; main component of LPG is **butane** (with propane).

Unsaturated hydrocarbons — Alkenes and Alkynes

Alkenes — contain at least one **C=C** double bond.

- General formula: **C_nH_{2n}**
- End with **-ene**.
- Sp² hybridisation, planar, 120° bond angle.
- Undergo **addition reactions**.

n	Formula	Name
2	C ₂ H ₄	Ethene (ethylene)
3	C ₃ H ₆	Propene
4	C ₄ H ₈	Butene

Alkynes — contain at least one **C≡C** triple bond.

- General formula: **C_nH_{2n-2}**
- End with **-yne**.

n	Formula	Name
2	C ₂ H ₂	Ethyne (acetylene)
3	C ₃ H ₄	Propyne

Distinguishing Tests

- **Bromine water (red-brown):**
 - Alkanes no change (in dark).
 - Alkenes/Alkynes decolourise bromine water (addition reaction).
- **Acidified KMnO₄ (purple, Baeyer's test):**
 - Alkenes decolourise.

- Alkanes no change.
- **Combustion:** all hydrocarbons burn to give $\text{CO}_2 + \text{H}_2\text{O}$.
 - Alkanes clean blue flame.
 - Alkenes/alkynes yellow sooty flame (more carbon).

18.3 Functional Groups

A **functional group** is an atom or group of atoms that gives a molecule its characteristic properties.

Class	Functional group	Suffix	Example
Alcohol	-OH	-ol	Ethanol $\text{C}_2\text{H}_5\text{OH}$
Aldehyde	-CHO	-al	Ethanal CH_3CHO
Ketone	$>\text{C}=\text{O}$	-one	Propanone CH_3COCH_3
Carboxylic acid	-COOH	-oic acid	Acetic acid CH_3COOH
Ester	-COO-	-oate	Ethyl acetate $\text{CH}_3\text{COOC}_2\text{H}_5$
Amine	-NH ₂	-amine	Methylamine CH_3NH_2
Amide	-CONH ₂	-amide	Acetamide CH_3CONH_2
Haloalkane	-X (F, Cl, Br, I)	halo-	Chloroethane $\text{C}_2\text{H}_5\text{Cl}$

18.4 IUPAC Naming

Steps:

1. Find the **longest carbon chain** containing the functional group.
2. **Number** the chain from the end giving the lowest number to the functional group or double/triple bond.
3. Name the parent: count C meth-, eth-, prop-, but-, pent-, hex-, ...
4. Identify the functional group and use suffix.
5. Number and name substituents (methyl-, ethyl-, chloro-, bromo-, etc.) with position numbers.

Examples

- $\text{CH}_3\text{-CH}_2\text{-OH}$ **Ethanol**
- $\text{CH}_3\text{-CH=CH-CH}_3$ **But-2-ene**
- $\text{CH}_3\text{-COOH}$ **Ethanoic acid** (acetic acid)
- $\text{CH}_3\text{-CH(OH)-CH}_3$ **Propan-2-ol**

18.5 Alcohols (R-OH)

- General formula: **$C_nH_{2n+1}OH$**
- Named with suffix **-ol**.

Important members

- **Methanol (CH_3OH)** — wood spirit; toxic; used as fuel, solvent.
- **Ethanol (C_2H_5OH)** — alcohol in drinks, spirit, fuel (gasohol), solvent, antiseptic.

Properties

- Polar (due to $-OH$) hydrogen bonding higher boiling point than alkanes of similar mass.
- Soluble in water (small ones).
- Flammable; burn with blue flame: $C_2H_5OH + 3 O_2 \rightarrow 2 CO_2 + 3 H_2O$.

Reactions of ethanol

- **With sodium:** $2 C_2H_5OH + 2 Na \rightarrow 2 C_2H_5ONa + H_2$
- **Dehydration (conc. H_2SO_4 , $170^\circ C$):** $C_2H_5OH \rightarrow C_2H_4 + H_2O$ (forms ethene).
- **Oxidation (acidified $K_2Cr_2O_7$):** $CH_3CH_2OH \rightarrow CH_3CHO$ (ethanal) CH_3COOH (acetic acid).
- **Esterification** (with carboxylic acid + conc. H_2SO_4): forms ester + water.

18.6 Carboxylic Acids ($R-COOH$)

- Functional group **$-COOH$** (carboxyl).
- Weak acids (do not fully ionise in water).
- React with alcohols to form **esters** (esterification, reversible).

Acetic acid (CH_3COOH)

- Colourless, pungent liquid.
- Vinegar = ~4–8% acetic acid in water.
- Used as preservative, in pickles, in making cellulose acetate.

Reactions

- With metal: $2 CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg + H_2$
- With carbonate: $2 CH_3COOH + Na_2CO_3 \rightarrow 2 CH_3COONa + H_2O + CO_2$
- With base: $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
- With alcohol: $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$ (esterification)

18.7 Esters ($R-COO-R'$)

- Formed from carboxylic acid + alcohol (esterification) with conc. H_2SO_4 as catalyst.

- Sweet fruity smell.
- Used in perfumes, flavouring agents, plasticisers.
- Hydrolysed back to acid + alcohol by water (with acid/alkali).

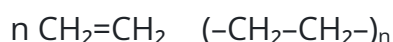
Example: **Ethyl acetate** ($\text{CH}_3\text{COOC}_2\text{H}_5$) — smells like pear drops.

18.8 Polymers

Polymerisation = small molecules (**monomers**) joining to form a large molecule (**polymer**).

Addition polymerisation

- Monomers with $\text{C}=\text{C}$ (alkenes) join by opening double bonds.
- Examples:
 - **Polyethene (polythene)** from ethene — plastic bags, bottles.
 - **Polypropene** from propene — ropes, carpets.
 - **PVC** from vinyl chloride — pipes, cables.
 - **Polystyrene** from styrene — cups, packaging.
 - **Teflon** from tetrafluoroethene — non-stick coating.



Condensation polymerisation

- Monomers join with loss of small molecule (water, HCl).
- Examples:
 - **Nylon** (from diamine + dicarboxylic acid) — clothing, ropes.
 - **Polyester / Terylene** (from diacid + dialcohol) — clothing, bottles.
 - **Proteins** are natural polyamides (amino acids).

18.9 Natural Organic Compounds

Polymer	Monomer	Found in
Cellulose	Glucose	Plant cell walls
Starch	Glucose	Potatoes, rice, wheat
Glycogen	Glucose	Animals (liver, muscles)
Proteins	Amino acids	Meat, eggs, beans
Nucleic acids	Nucleotides	DNA, RNA
Natural rubber	Isoprene	Rubber tree

Silk	Amino acids	Silkworm cocoons
Wool	Amino acids	Sheep

18.10 Fossil Fuels

Formed from the remains of dead plants and animals buried millions of years ago, under heat and pressure.

- **Coal** — solid; mainly carbon. Burns to give CO₂, heat. Used in power plants, steel industry.
- **Petroleum (crude oil)** — liquid mixture of hydrocarbons; refined by fractional distillation in **oil refineries**.
- **Natural gas** — mainly methane; transported by pipelines and as LNG.

Fractional distillation of petroleum

Crude oil heated vaporised rises in fractionating tower condenses at different heights:

- **LPG** (lowest, ~40 °C) — cooking gas.
- **Petrol/gasoline** (~70 °C) — cars.
- **Kerosene** (~170 °C) — jet fuel, lamps.
- **Diesel** (~250 °C) — heavy vehicles.
- **Lubricating oil** (~300 °C) — machines.
- **Paraffin wax** (~370 °C) — candles.
- **Bitumen** (residue) — road surfacing.

The smaller the molecule the more volatile the lower the boiling point collected at the top of the tower.

18.11 Harmful Effects of Fossil Fuel Use

- **Air pollution** — SO₂ (acid rain), CO₂ (global warming), particulate matter (respiratory diseases).
- **Water pollution** — oil spills kill marine life.
- **Greenhouse effect** climate change.
- **Non-renewable** — will run out in 50–100 years.

18.12 Renewable Alternatives

- **Solar energy** — sunlight for heat and electricity.
- **Wind energy** — wind turbines.
- **Hydropower** — flowing water.
- **Biomass** — ethanol from sugarcane, biogas from waste.
- **Hydrogen fuel** — water + electricity H₂ fuel cell electricity + water (no pollution).

Chapter 19 — Chemicals used in Daily Life

19.1 Introduction

Modern life depends on chemicals. From toothpaste to medicines, from soap to paint, we use thousands of chemicals every day. Some are beneficial; some are harmful if misused.

This chapter covers the major classes of chemicals we encounter daily.

19.2 Soap and Detergents

Soap

- Made by **saponification** of fats/oils with NaOH (gives sodium salt) or KOH (gives potassium salt).
- Fat/Oil + NaOH → Soap + Glycerol

Example: Tristearin + 3 NaOH → 3 Sodium stearate (soap) + Glycerol

- Sodium stearate: $\text{C}_{17}\text{H}_{35}\text{COONa}$.

How soap cleans

- Soap molecule has a **long hydrocarbon chain (tail, hydrophobic / water-hating)** and a **$\text{COO}^- \text{Na}^+$ group (head, hydrophilic / water-loving)**.
- Tail sticks to grease/dirt; head sticks to water.
- This forms **micelles** around dirt → dirt lifted off → carried away by water.

tail (hydrophobic) head (hydrophilic)

dirt/grease water

- Soap makes water "wetter" — lowers **surface tension**.
- Soap works best in **soft water**. In **hard water** (containing $\text{Ca}^{2+}/\text{Mg}^{2+}$), it forms **scum** (insoluble Ca/Mg salts of fatty acid) and is wasted.

Detergents

- Synthetic cleaning agents. Made from petroleum products (long-chain hydrocarbons + sulfuric acid + NaOH).
- Work like soap but better in hard water — they don't form scum because their calcium/magnesium salts are soluble.

- May contain **phosphates** — cause **eutrophication** in water bodies.
- **Biodegradable** detergents break down in nature; non-biodegradable ones cause pollution.

Difference between soap and detergent

Soap	Detergent
Made from natural fats/oils	Made from petroleum

- Sodium/potassium salt of long fatty acid | Sodium salt of long-chain sulphonic acid / alkyl benzene sulphonate |
- Forms scum in hard water | Works in hard water | | Biodegradable | Some non-biodegradable |

19.3 Food Chemistry

Food additives

Substances added to food to improve its **taste, colour, texture, shelf life, or nutritional value**.

Types

1. Food preservatives — prevent spoilage by killing/inhibiting microbes.

- Salt, sugar, vinegar, oil (traditional).
- Sodium benzoate ($\text{C}_6\text{H}_5\text{COONa}$), potassium metabisulphite, citric acid.

2. Antioxidants — prevent oxidation (rancidity of fats).

- BHA (Butylated Hydroxy Anisole), BHT (Butylated Hydroxy Toluene).

3. Artificial sweeteners — sweet taste, no/low calories.

- Saccharin, aspartame, sucralose. (Sugar = glucose + fructose = natural.)

4. Food colourants — make food attractive.

- Turmeric (yellow), saffron, caramel.
- Synthetic: tartrazine, sunset yellow (some banned due to hyperactivity in children).

5. Flavour enhancers — boost taste.

- MSG (MonoSodium Glutamate) — common in Chinese food; some people sensitive.

6. Nutritional additives — fortify with vitamins/minerals.

- Iodised salt (prevents goitre).
- Iron-fortified flour (prevents anaemia).

Adulterants

Adulterants are substances added to food to **cheat** — increase quantity or hide poor quality.

- Water in milk, urea in milk, stones in rice, papaya seeds in black pepper, brick powder in chilli powder, vanaspati ghee in pure ghee.
- Detected by simple tests or sophisticated lab analysis.

In Nepal, **Food Act 2023 (1976)** regulates food quality.

19.4 Medicines

A **medicine** is a chemical substance used to **diagnose, treat, cure, or prevent disease**.

Analgesics (pain killers)

- **Non-narcotic:** aspirin, paracetamol, ibuprofen — reduce pain, fever; not addictive.
- **Narcotic:** morphine, codeine — strong pain relief, addictive, used only in severe pain (e.g., cancer).

Antipyretics

- Reduce fever. Example: paracetamol.

Antibiotics

- Kill or stop growth of **bacteria**.
- Examples: penicillin (from *Penicillium* mould), streptomycin, tetracycline, amoxicillin, ciprofloxacin.
- **Do not work against viruses** (so antibiotics don't cure cold/flu).
- **Alexander Fleming** discovered penicillin in 1928.
- **Misuse** (e.g., not completing the course) leads to **antibiotic resistance** — bacteria evolve to survive.

Antiseptics and Disinfectants

- **Antiseptic** — applied to living tissue (skin) to kill microbes. Examples: dettol, iodine tincture, hydrogen peroxide.
- **Disinfectant** — used on non-living surfaces (floors, instruments). Examples: phenol, formaldehyde, chlorine.

Vaccines

- Inactive or weakened pathogen injected body makes antibodies future infections fought off.

- Examples: polio, measles, BCG (tuberculosis), DPT (Diphtheria, Pertussis, Tetanus), hepatitis.

19.5 Cleansing Agents — Beyond Soap

- **Toothpaste** — mild abrasive (CaCO_3), fluoride (to prevent cavities), humectant, flavour.
- **Shampoo** — detergent + conditioner.
- **Laundry detergent** — surfactant + builder (boosts cleaning) + optical brightener + fragrance.
- **Bleach** — sodium hypochlorite (NaOCl) — oxidises stains and kills microbes.
- **Glass cleaner** — usually contains isopropyl alcohol + ammonia + surfactant.

19.6 Chemicals in Cosmetics

- **Talcum powder** — talc (hydrated magnesium silicate).
- **Kohl (surma)** — can contain lead — harmful.
- **Lipstick** — wax, oil, pigment.
- **Perfume** — alcohol + fragrance oils.
- **Sunscreen** — UV-absorbing compounds.

Many cosmetics contain harmful heavy metals (lead, mercury) — must check labels.

19.7 Pesticides and Insecticides

Used in agriculture to kill pests (insects, weeds, fungi, rodents).

Types

- **Insecticides** — DDT (now banned in many countries), malathion, organophosphates.
- **Herbicides** — 2,4-D, glyphosate.
- **Fungicides** — Bordeaux mixture ($\text{CuSO}_4 + \text{Ca}(\text{OH})_2$), sulfur dust.
- **Rodenticides** — warfarin, zinc phosphide.

Problems

- **Bioaccumulation** — pesticide builds up along food chain (DDT famously found in eggs of birds).
- **Pest resistance** — pests evolve to survive.
- **Harmful to non-target species** — bees, birds, fish.
- **Water pollution.**

Alternatives

- **Biological control** — using natural predators (e.g., ladybugs eat aphids).
- **Integrated Pest Management (IPM)** — mix of methods.

- **Organic farming** — no synthetic pesticides.

19.8 Chemicals in Agriculture

- **Fertilisers** — supply N, P, K (NPK) to soil.
 - Nitrogenous: urea $[(\text{NH}_2)_2\text{CO}]$, ammonium nitrate, ammonium sulphate.
 - Phosphatic: superphosphate, triple superphosphate.
 - Potassic: muriate of potash (KCl).
- **Manure, compost, vermicompost, green manure** — organic alternatives.

19.9 Drugs of Abuse

Drug	Source	Effect
Opium / Heroin	Poppy	Pain relief sedation addiction
Marijuana / Ganja	Cannabis plant	Relaxation altered perception addiction
Cocaine	Coca plant	Stimulation addiction
Tobacco (nicotine)	Tobacco plant	Stimulant addiction cancer, heart disease
Alcohol (ethanol)	Fermentation	Relaxation addiction liver disease
LSD, MDMA	Synthetic	Hallucinations severe damage

Harmful effects of drug abuse

- Damages brain, liver, kidneys.
- Family/social problems.
- Addiction — compulsive use despite harm.
- HIV from shared needles.
- Crime.

In Nepal, **Drugs Act 1976** controls drugs.

19.10 Tobacco and Alcohol

Tobacco

- Contains **nicotine** (addictive stimulant) and **tar** (causes cancer).
- Smoking causes **lung cancer, bronchitis, heart disease, stroke**.
- Chewing tobacco causes **oral cancer**.
- Passive smoking (inhaling others' smoke) also harmful.

Alcohol

- Ethanol is the drinkable form.
- Short-term effects: relaxation, loss of coordination, slurred speech.
- Long-term effects: liver cirrhosis, brain damage, heart disease, addiction.
- Pregnant women drinking causes **foetal alcohol syndrome** in baby.

19.11 Plastics — Boon and Bane

Types

- **Thermoplastics** — melt on heating, can be remoulded. Examples: polythene, PVC, nylon.
- **Thermosetting plastics** — once set, cannot be remoulded. Examples: bakelite, melamine.

Uses

- Cheap, durable, versatile, hygienic.
- Bags, bottles, pipes, toys, furniture, parts of vehicles, medical devices.

Problems

- **Non-biodegradable** — takes 500–1000 years to decompose.
- Chokes animals, fills landfills, pollutes oceans.
- Burning releases toxic gases (CO, dioxins).
- Microplastics now found in drinking water, food, even human blood.

Solutions

- **Reduce, reuse, recycle** (3 R's).
- **Biodegradable plastics** (from corn starch, sugarcane).
- Ban on single-use plastics.
- Proper waste segregation.
- **Plastic recycling codes** 1–7 on containers.

19.12 Glass

- Made from sand (SiO_2) + soda ash (Na_2CO_3) + limestone (CaCO_3).
- Recyclable indefinitely without loss of quality.
- Used for bottles, windows, lab equipment, fibreglass.

19.13 Cement and Concrete

- **Cement** — made by heating limestone + clay in a kiln grinding.

- **Concrete** = cement + sand + gravel + water.
- Foundation of modern construction.

19.14 Paints and Varnishes

- **Paints** — pigment + binder + solvent + additives.
- Used to protect and decorate surfaces.
- Lead-based paints are toxic — banned in many countries.

19.15 Dyes

- Synthetic dyes (aniline dyes) colour fabrics, paper, food.
- Examples: indigo, malachite green, congo red.

19.16 Chemicals in Photography

- **Silver bromide (AgBr)** is light-sensitive exposed forms image developed fixed with sodium thiosulphate.
- Digital cameras replaced film but chemistry still used in printing.

19.17 Environmental Impact and Safety

- Many daily-use chemicals are **toxic, carcinogenic, or harmful to environment**.
- Always read labels, follow instructions.
- Store away from children.
- Don't pour chemicals down drains.
- Use gloves when handling strong chemicals.

19.18 Sustainable Choices

- Choose **biodegradable** products.
- Use **natural** cleaners (vinegar, baking soda, lemon) where possible.
- Reduce plastic use.
- Support organic farming.
- Recycle paper, glass, metal.

Closing Note

This completes the chapter-by-chapter notes for **Science and Technology, Grade 10 (Part-I)** aligned with the CDC Nepal curriculum.

Use these notes for:

- **Daily study** alongside your textbook.
- **Quick revision** before exams.
- **Concept understanding** — diagrams and tables aid memory.
- **Lab work** — practicals will reinforce these concepts.

Remember: science is not memorising facts; it is **understanding how and why**. Read your textbook, do activities, ask questions, and discuss with friends. The SEE exam tests understanding and application, not just rote learning.

Best of luck with your exam!