

TIMSS 2023 Science Framework for the fourth and eighth grades extends the 28-year history of TIMSS assessments, beginning in 1995 and taking place every four years since. TIMSS 2023 is the eighth assessment in the series.

The TIMSS 2023 science frameworks are similar to those used in TIMSS 2019. However, there have been minor updates to reflect countries' evolving science curricula, frameworks, and learning goals as reported in the *TIMSS 2019 Encyclopedia*.¹ TIMSS 2023 completes the transition to digital assessment, which began in TIMSS 2019. The science frameworks have been updated to reflect that TIMSS 2023 will









1. Ways of maintaining good health:
 - A. Describe everyday behaviors that promote good health (e.g., a balanced diet, exercising regularly, brushing teeth, getting enough sleep, wearing sunscreen); identify common food sources included in a balanced diet (e.g., fruits, vegetables, grains).
 - B. Relate the transmission of common communicable diseases to human contact (e.g., touching, sneezing, coughing); identify or describe some methods of preventing disease transmission (e.g., vaccination, washing hands, keeping a physical distance from people who are sick).

At the fourth grade, students learn how many physical phenomena that they observe in their everyday lives can be explained through an understanding of physical science concepts. The topic areas for the physical science content domain at fourth grade are:

- Classification and properties of matter and changes in matter
- Forms of energy and energy transfer
- Forces and motion

Fourth grade students should have an understanding of physical states of matter (solid, liquid, and gas), as well as common changes in the state and form of matter; this forms a foundation for the study of both chemistry and physics in the middle and upper grades. At this level, students also should know



3. Magnetic attraction and repulsion:
 - A. Recognize that magnets have two poles and that like poles repel and opposite poles attract.
 - B. Recognize that magnets can be used to attract some metal objects.
4. Physical changes observed in everyday life:
 - A. Identify observable changes in materials that do not result in new materials with different properties (e.g., dissolving, crushing an aluminum can).
 - B. Recognize that matter can be changed from one state to another by heating or cooling; describe changes in the state of water (i.e., melting, freezing, boiling, evaporation, and condensation).
 - C. Identify ways of increasing how quickly a solid material dissolves in a given amount of water (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces); distinguish between weak and strong concentrations of simple solutions (e.g., water sweetened with one versus two lumps of sugar).
5. Chemical changes observed in everyday life:
 - A. Identify observable changes in materials that make new materials with different properties (e.g., decaying, such as food spoiling; burning; rusting).
1. Common sources and uses of energy:
 - A. Identify sources of energy (e.g., the Sun, flowing water, wind, coal, oil, gas), and recognize that energy is needed for movement and transportation, manufacturing, heating, lighting, and powering electronic devices1(€)1 (n)19 (t a)9 oen-Šic devices1(€)1 (n)19 (t a)9 oen-Šic den-Šhen7 45.



1. Familiar forces and the motion of objects:
 - A. Identify gravity as the force that draws objects to Earth.
 - B. Recognize that forces (i.e., pushing and pulling) may cause an object to change its motion; compare the effects of these forces (pushes and pulls) of different strengths in the same or opposite directions acting on an object; and recognize that friction force works against the direction of motion (e.g., friction working against a push or a pull makes it more difficult to move an object along a surface).
2. Simple machines:
 - A. Recognize that simple machines, (e.g., levers, pulleys, gears, ramps) help make motion easier (e.g., make lifting things easier, reduce the amount of force required, change the distance, change the direction of the force).

Earth science is the study of Earth and its place in the Solar System, and at fourth grade focuses on the study of phenomena and processes that students can observe in their everyday lives. While there is no single picture of what constitutes an Earth science curriculum that applies to all countries, the three topic areas included in this domain are generally considered to be important for students at the fourth

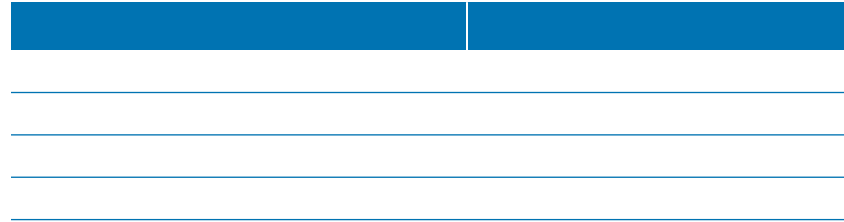


3. Earth's history:

A. Recognize that wind and water change Earth's landscape and that some features of Earth's



Four major content domains define the science content for the TIMSS Science eighth grade assessment: biology, chemistry, physics, and Earth science. Exhibit 2.3 shows the target percentages for each of the four content domains in the TIMSS 2023 science assessment.



Each of these content domains includes several major topic areas, and each topic area in turn includes one or more topics. Each topic is further described by specific objectives that represent the students' expected knowledge, abilities, and skills assessed within each topic. Across the eighth grade assessment, each objective receives approximately equal weight in terms of assessment items. The verbs used in the objectives are intended to represent typical performances expected of eighth grade students, but are not intended to limit performances to a particular cognitive domain. Each objective can be assessed drawing on each of the three cognitive domains (knowing, applying, and reasoning). Some objectives include additional parenthetical information. Illustrative examples appear after an "e.g.," such as in "Locate and identify major organs (e.g., lungs, stomach, brain) and the components of major organ systems (e.g., respiratory system, digestive system) in the human body." In some cases, the additional information indicates the scope of the objective appropriate for eighth grade students and appears after an "i.e.," such as in "Describe the basic process of photosynthesis (i.e., requires light, carbon dioxide, water, and chlorophyll; produces glucose/sugar; and releases oxygen)."

At the eighth grade, students build on the foundational life science knowledge they learned in the primary grades, and develop an understanding of many of the most important concepts in biology. The biology domain includes six topic areas:

- Characteristics and life processes of organisms
- Cells and their functions
- Life cycles, reproduction, and heredity
- Diversity, adaptation, and natural selection
- Ecosystems
- Human health



Concepts learned in each of these topic areas are essential for preparing students for more advanced study. Eighth grade students are expected to understand how structure relates to function in organisms. They also should have a foundational understanding of cell structure and function and the processes of photosynthesis and cellular respiration. At this level, the study of reproduction and heredity provides a foundation for later, more advanced study of molecular biology and molecular genetics. Learning the concepts of adaptation and natural selection provides a foundation for understanding evolution, and an understanding of processes and interactions in ecosystems is essential for students to begin to think



- C. Recognize that cell walls and chloroplasts differentiate plant cells from animal cells.
 - D. Explain that tissues, organs, and organ systems are formed from groups of cells with specialized structures and functions.
2. The processes of photosynthesis and cellular respiration:
- A. Describe the basic process of photosynthesis (i.e., requires light, carbon dioxide, water, and chlorophyll; produces glucose/sugar; and releases oxygen).
 - B.



- B. Describe the flow of energy in an ecosystem (e.g., energy flows from producers to consumers, and only a small part of the energy is passed from one level to the next); construct or interpret energy pyramids.
2. The cycling of water, oxygen, and carbon in ecosystems:
 - A.





describe that the elements are arranged in order of the number of protons in the nuclei of the atoms of each element.

- B. Recognize that an element's properties (e.g., metal or non-metal, reactivity) can be predicted from its location in the periodic table (i.e., row, or period, and column, or group/family) and that elements in the same group have some properties in common.
1. Physical and chemical properties of matter:
 - A. Distinguish between physical and chemical properties of matter.
 - B. Relate uses of materials to their physical properties (e.g., melting point, boiling point, solubility, thermal conductivity).
 - C. Relate uses of materials to their chemical properties (e.g., tendency to rust, flammability).
 2. Physical and chemical properties as a basis for classifying matter:
 - A. Classify substances according to physical properties that can be demonstrated or measured (e.g., density, melting or boiling point, solubility, magnetic properties, electrical or thermal



2. Matter and energy in chemical reactions:
 - A. Recognize that matter is conserved during a chemical reaction and that all of the atoms present at the beginning of the reaction are present at the end of the reaction, but they are rearranged to form new substances.
 - B. Recognize that some chemical reactions release energy (heat) while others absorb it, and classify common chemical reactions (e.g., burning, neutralization, the mixing of substances in a chemical cold pack) as either releasing heat or absorbing energy (heat).
 - C. Recognize that chemical reactions occur at different rates and that the rate of reaction can be affected by changing the conditions under which the reaction is taking place (i.e., surface area, temperature, and concentration).
3. Chemical bonds:
 - A.





2. Properties of sound:

A. Describe or identify some basic properties of sound (i.e., is a wave phenomenon caused



- D. Predict qualitative one-dimensional changes in motion (speed and direction) of an object based on the forces acting on it; recognize and describe how the force of friction affects motion (e.g., the contact area between surfaces can increase friction and impede motion).

Topics covered in the teaching and learning of Earth science draw on the fields of geology, astronomy, meteorology, hydrology, and oceanography, and are related to concepts in biology, chemistry, and physics. Although separate courses in Earth science covering all of these topics are not taught in all countries, it is expected that understandings related to Earth science topic areas will have been included in a science curriculum covering the physical and life sciences or in separate courses such as geography and geology. The *TIMSS 2023 Science Framework* identifies the following topic areas that are universally considered to be important for students at the eighth grade to understand as they learn about the planet on which they live and its place in the universe:

- Earth's structure and physical features
- Earth's processes, cycles, and history
- Earth's resources, their use, and conservation
- Earth in the Solar System and the universe

Eighth grade students are expected to have some general knowledge about the structure and physical features of Earth, including Earth's structural layers, and the atmosphere. Students also should have a conceptual understanding of processes, cycles, and patterns, including geological processes that have occurred over Earth's history, the water cycle, and patterns of weather and climate. Students should demonstrate knowledge of Earth's resources and their use and conservation, and relate this knowledge to practical solutions to resource management issues. At this level, the study of Earth and the Solar System includes understanding how observable phenomena relate to the movements of Earth and the Moon, and describing the features of Earth, the Moon, and other planets.

1. Earth's structure and physical characteristics:
 - A. Describe the structure of the Earth (i.e., crust, mantle, inner core, and outer core) and the physical characteristics of these distinct parts.
 - B. Describe the distribution of water on Earth in terms of its physical state (i.e., ice, water, and water vapor), and fresh versus salt water.
2. Components of Earth's atmosphere and atmospheric conditions:
 - A. Recognize that Earth's atmosphere is a mixture of gases; identify the relative abundance of its main components (i.e., nitrogen, oxygen, water vapor, and carbon dioxide), relate these components to everyday life processes involving oxygen, water vapor, and carbon dioxide (e.g., human lung function, photosynthesis).
 - B. Relate changes in atmospheric conditions (i.e., temperature and pressure) to changes in altitude.



1. Geological processes:
 - A. Describe the general processes involved in the rock cycle (e.g., the cooling of lava, heat and pressure transforming sediment into rock, weathering, erosion).
 - B. Identify or describe changes to Earth's surface (e.g., mountain building), resulting from major geological events (e.g., glaciation, the movement of tectonic plates and subsequent earthquakes and volcanic eruptions).
 - C. Explain the formation of fossils and fossil fuels; use evidence from the fossil record to explain how the environment has changed over long periods of time.
2. Earth's water cycle:
 - A. Describe the processes in Earth's water cycle (i.e., evaporation, condensation into clouds, transportation, and precipitation) and recognize the Sun as the source of energy for the water cycle.
 - B. Describe the role of cloud movement and water flow in the circulation and renewal of fresh water on Earth's surface.
3. Weather and climate:
 - A. Distinguish between weather (i.e., day-to-day variations in temperature, humidity, precipitation in the form of rain or snow, clouds, and wind) and climate (i.e., long-term typical weather patterns in a geographic area).
 - B. Interpret data or maps of weather patterns to identify climate types; relate the climate and seasonal variations in weather patterns to global and local factors (e.g., latitude, altitude, geography).
 - C. Identify or describe evidence for climate changes (e.g., changes related to ice ages, changes related to global warming).
1. Managing Earth's resources:
 - A.



1. Observable phenomena on Earth resulting from movements of Earth and the Moon:
 - A. Describe the effects of the Earth's annual revolution around the Sun, given the tilt of its axis (e.g., different seasons, different constellations visible at different times of the year).
 - B. Recognize that tides are caused by the gravitational pull of the Moon, and relate phases of the Moon and eclipses to the relative positions of Earth, the Moon, and the Sun.
2. The Sun, stars, Earth, Moon, and planets:
 - A. Recognize that the Sun is a star and provides light and heat to each member of the Solar System; explain that the Sun and other stars produce their own light, but that other members of the Solar System are visible because of light reflected from the Sun.
 - B. Compare and contrast certain physical features of Earth with those of the Moon and other planets (e.g., presence and composition of an atmosphere, average surface temperature, presence of water, mass, gravity, distance from the Sun, period of revolution and rotation, ability to support life); recognize that the force of gravity keeps planets and moons in their orbits.

The cognitive dimension is divided into three domains that describe the thinking processes students are expected to engage in when encountering the science items developed for TIMSS 2023. The first domain, *knowing*, addresses the student's ability to recall, recognize, describe, and provide examples of facts, concepts, and procedures that are necessary for a solid foundation in science. The second domain, *applying*, focuses on using this knowledge to compare, contrast, and classify groups of objects or materials; relating knowledge of a science concept to a specific context; generating explanations; and solving practical problems. The third domain, *reasoning*, includes using evidence and science understanding to analyze, synthesize, and generalize, often in unfamiliar situations and complex contexts.

These three cognitive domains are used at both grades, however, the target percentages for each domain vary between fourth and eighth grade in accordance with the increased cognitive ability, instruction, experience, and breadth and depth of understanding of students at the higher grade level. The percentage of items that involve knowing is higher at the fourth grade compared to the eighth grade, while the percentage of items that ask students to engage in reasoning is higher at the eighth grade compared to the fourth grade. While there is some hierarchy in the thinking processes across the three cognitive domains (from knowing to applying to reasoning), each cognitive domain contains items









TIMSS assesses the science practices primarily with the science PSIs, in which students conduct extended investigations and inquiries, and in doing so engage in one or more of the science practices. However, regular items in TIMSS can also incorporate one or more of the science practices.



