

Science Content Domains—Eighth Grade

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 2019 science assessment.

Exhibit 2.3: Target Percentages of the TIMSS 2019 Science Assessment Devoted to Content Domains at the Eighth Grade

Eighth Grade Content Domains	Percentages
Biology	35%
Chemistry	20%
Physics	25%
Earth Science	20%

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).

Biology

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 about how to develop solutions to many environmental challenges. Finally, developing a science-based understanding of human health enables students to improve the condition of their lives and the lives of others.

Characteristics and Life Processes of Organisms

1. Differences among major taxonomic groups of organisms:
 - A. Identify the defining characteristics that differentiate among major taxonomic groups of organisms (i.e., plants, animals, fungi, mammals, birds, reptiles, fish, amphibians, and insects).
 - B. Recognize and categorize organisms that are examples of major taxonomic groups of organisms (i.e., plants, animals, fungi, mammals, birds, reptiles, fish, amphibians, and insects).
2. Structures and functions of major organ systems:
 - A. 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.
 - B. Compare and contrast major organs and major organ systems in humans and other vertebrates.
 - C. Explain the role of major organs and major organ systems in sustaining life, such as those involved in circulation and respiration.
3. Physiological processes in animals:
 - A. Recognize responses of animals to external and internal changes that work to maintain stable body conditions (e.g., increased heart rate during exercise, feeling thirsty when dehydrated, feeling hungry when requiring energy, sweating in heat, shivering in cold).

Cells and Their Functions

1. The structures and functions of cells:
 - A. Explain that living things are made of cells that both carry out life functions and reproduce by division.
 - B. Identify major cell structures (i.e., cell wall, cell membrane, nucleus, chloroplast, vacuole, and mitochondria) and describe the primary functions of these structures.
 - 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. Describe the basic process of cellular respiration (i.e., requires oxygen and glucose/sugar; produces energy; and releases carbon dioxide and water).

Life Cycles, Reproduction, and Heredity

- 1. Life cycles and patterns of development:
 - A. Compare and contrast the life cycles and patterns of growth and development of different types of organisms (i.e., mammals, birds, amphibians, insects, and plants).
- 2. Sexual reproduction and inheritance in plants and animals:
 - A. Recognize that sexual reproduction involves the fertilization of an egg cell by a sperm cell to produce offspring that are similar but not identical to either parent; relate the inheritance of traits to organisms passing on genetic material to their offspring.
 - B. Recognize that an organism's traits are encoded in its DNA; recognize that DNA is genetic information found in chromosomes located in the nucleus of each cell.
 - C. Distinguish inherited characteristics from acquired or learned characteristics.

Diversity, Adaptation, and Natural Selection

- 1. Variation as the basis for natural selection:
 - A. Recognize that variations in physical and behavioral characteristics among individuals in a population give some individuals an advantage in surviving and passing on their characteristics to their offspring.
 - B. Relate species survival or extinction to reproductive success in a changing environment (natural selection).
- 2. Evidence for changes in life on Earth over time:
 - A. Draw conclusions about the relative length of time major groups of organisms have existed on Earth using fossil evidence.
 - B. Describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time, and recognize that the degree of similarity of characteristics provides evidence of common ancestry.

Ecosystems

1. The flow of energy in ecosystems:
 - A. Identify and provide examples of producers, consumers, and decomposers; draw or interpret food web diagrams.
 - B. Describe the flow of energy in an ecosystem (i.e., energy flows from producers to consumers, and only part of the energy is passed from one level to the next); draw or interpret energy pyramids.
2. The cycling of water, oxygen, and carbon in ecosystems:
 - A. Describe the role of living things in cycling water through an ecosystem (i.e., plants take in water from the soil and give off water through their leaves; and animals take in water and release water during respiration and as waste).
 - B. Describe the role of living things in cycling oxygen and carbon through an ecosystem (i.e., plants take in carbon dioxide from the air and release oxygen into the air as part of photosynthesis and store carbon in their cells; and animals take in oxygen from the air and release carbon dioxide into the air as part of respiration).
3. Interdependence of populations of organisms in an ecosystem:
 - A. Describe and provide examples of competition among populations or organisms in an ecosystem.
 - B. Describe and provide examples of predation in an ecosystem.
 - C. Describe and provide examples of symbiosis among populations of organisms in an ecosystem (e.g., birds or insects pollinating flowers, birds eating insects on deer or cattle).
4. Factors affecting population size in an ecosystem:
 - A. Describe factors that affect the growth of plants and animals; identify factors that limit population size (e.g., disease, predators, food resources, drought).
 - B. Predict how changes in an ecosystem (e.g., changes in the water supply, the introduction of a new population, hunting, migration) can affect available resources, and thus the balance among populations.
5. Human impact on the environment:
 - A. Describe and explain ways in which human behavior (e.g., re-planting forests, reducing air and water pollution, protecting endangered species) can have positive effects on the environment.

- B. Describe and explain ways in which human behavior (e.g., allowing factory waste water to enter water systems, burning fossil fuels that release greenhouse gases and pollutants into the air) can have negative effects on the environment; describe and provide examples of the effects of air, water, and soil pollution on humans, plants, and animals (e.g., water pollution can reduce plant and animal life in the water system).

Human Health

1. Causes, transmission, and prevention of, and resistance to diseases:
 - A. Describe causes, transmission, and prevention of common diseases (e.g., influenza, measles, malaria, HIV).
 - B. Describe the role of the body's immune system in resisting disease and promoting healing (i.e., antibodies in the blood help the body resist infection and white blood cells fight infection).
2. The importance of diet, exercise, and other lifestyle choices:
 - A. Explain the importance of diet, exercise, and other lifestyle choices in maintaining health and preventing illness (e.g., heart disease, high blood pressure, diabetes, skin cancer, lung cancer).
 - B. Identify the dietary sources and roles of nutrients in a healthy diet (i.e., vitamins, minerals, proteins, carbohydrates, and fats).

Chemistry

At the eighth grade, students' study of chemistry extends beyond developing an understanding of everyday phenomena to learning the central concepts and principles that are needed for understanding practical applications of chemistry and undertaking later, more advanced study. The chemistry domain includes three topic areas:

- Composition of matter
- Properties of matter
- Chemical change

The composition of matter topic area focuses on differentiating elements, compounds, and mixtures and understanding the particulate structure of matter. Included in this area also is the use of the periodic table as an organizing principle for the elements. At a more macroscopic level, the properties of matter topic area focuses on distinguishing between physical and chemical properties of matter and understanding the properties of mixtures and solutions and the properties of acids and bases. The study of chemical change focuses on the characteristics of chemical changes and the conservation of matter during chemical changes.

3. Effects of forces:
 - A. Describe the functioning of simple machines (e.g., levers, inclined planes, pulleys, gears).
 - B. Explain floating and sinking in terms of density differences and the effect of buoyant force.
 - C. Describe pressure in terms of force and area; describe effects related to pressure (e.g., water pressure increasing with depth, a balloon expanding when inflated).
 - 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).

Earth Science

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 2019 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.

Earth’s Structure and Physical Features

1. Earth’s structure and physical characteristics:
 - A. Describe the structure of the Earth (i.e., crust, mantle, and 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 processes.
 - B. Relate changes in atmospheric conditions (i.e., temperature and pressure) to changes in altitude.

Earth's Processes, Cycles, and History

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, 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.
 - C. Relate the climate and seasonal variations in weather patterns to global and local factors (e.g., latitude, altitude, geography).
 - D. Identify or describe evidence for climate changes (e.g., changes that occur during ice ages, changes that are related to global warming).

Earth's Resources, Their Use and Conservation

1. Managing Earth's resources:
 - A. Provide examples of Earth's renewable and nonrenewable resources.
 - B. Discuss advantages and disadvantages of different energy sources (e.g., sunlight, wind, flowing water, geothermal, oil, coal, gas, nuclear).
 - C. Describe methods of conservation of Earth's resources and methods of waste management (e.g., recycling).
2. Land and water use:
 - A. Explain how common methods of land use (e.g., farming, logging, mining) can affect land and water resources.
 - B. Explain the importance of water conservation, and describe methods for ensuring that fresh water is available for human activities (e.g., desalination, purification).

Earth in the Solar System and the Universe

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.