Section 4.4
Learning Standards

4.4.1 Curricular Goals and Competencies

This section lays out the Learning Standards (Curricular Goals and Competencies) for Science as an integrated Curricular Area.

In the Middle Stage and Grades 9 and 10 of the Secondary Stage, Science is taught using integrated approach. This integrated approach develops fundamental capacities related to the disciplines of Biology, Chemistry, Physics, and Earth Science while the use of connections across them helps students appreciate the interrelations between these subjects and make sense of their observations and experiences.

At all Stages, along with conceptual understanding, the capacities of scientific inquiry are developed as age appropriate. These concepts and capacities are chosen both from a disciplinary perspective and in terms of what is useful and necessary in their everyday lives. Students thereby understand the world around them with increasing depth, explore scientific questions at different levels through discussion and experimentation, and learn to communicate this understanding in different ways.

It is important to note that the Curricular Goals are interdependent, and not separate curricular pieces of study. For example, the Curricular Goals CG-1 (explore matter) and CG-6 (how to do Science) given in the Middle Stage would need to happen together, say through a project, for a student to attain both Goals.

4.4.1.1 Middle Stage

CG-1 Explores the world of matter and its constituents, properties, and behaviour	C-1.1	Classifies matter based on observable physical (solid, liquid, gas, shape, volume, density, transparent, opaque, translucent, magnetic, non-magnetic, conducting, non-conducting) and chemical (pure, impure; acid, base; metal, non-metal; element, compound) characteristics
	C-1.2	Describes changes in matter (physical and chemical) and uses particulate nature to represent the properties of matter and the changes
	C-1.3	Explains the importance of measurement and measures physical properties of matter (such as, volume, weight, temperature, density) in indigenous, non-standard and standard units using simple instruments
	C-1.4	Observes and explains the phenomena caused due to differences in pressure, temperature, and density (e.g., breathing, sinking-floating, water pumps in homes, cooling of things, formation of winds)

CG-2 Explores the physical world in scientific and mathematical terms	C-2.1	Describes one-dimensional motion (uniform, non-uniform, horizontal, vertical) using physical measurements (position, speed, and changes in speed) through mathematical and diagrammatic representations
	C-2.2	Describes how electricity works through manipulating different elements in simple circuits and demonstrates the heating and magnetic effects of electricity
	C-2.3	Describes the properties of a magnet (natural and artificial; Earth as a magnet)
	C-2.4	Demonstrates rectilinear propagation of light from different sources (natural, artificial, reflecting surfaces), verifies the laws of reflection through manipulation of light sources and objects and the use of apparatus and artefacts (such as, plane and curved mirrors, pinhole camera, kaleidoscope, periscope)
	C-2.5	Observes and identifies celestial objects (stars, planets, natural and artificial satellites, constellations, comets) in the night sky using a simple telescope and images or photographs, and explains their role in navigation, calendars, and other phenomena (phases of the moon, eclipse, life on earth)
CG-3 Explores the living world in scientific terms	C-3.1	Describes the diversity of living things observed in the natural surroundings (insects, earthworms, snails, birds, mammals, reptiles, spiders, diverse plants, and fungi), including at a smaller scale (microscopic organisms)
	C-3.2	Distinguishes the characteristics of living organisms (need for nutrition, growth and development, need for respiration, response to stimuli, reproduction, excretion, cellular organisation) from non-living things
	C-3.3	Analyses patterns of relationships between living organisms and their environments in terms of dependence on and response to each other
	C-3.4	Explains the conditions suitable for sustaining life on Earth and other planets (atmosphere; suitable temperature-pressure, light; properties of water)
CG-4 Understands the components of health, hygiene, and well-being	C-4.1	Undertakes a nutrition-based analysis of food components with special reference to Indian culinary practices and modern understanding of nutrition, and explains the effect of nutrition on health
	C-4.2	Examines different dimensions of diversity of food, sources, nutrients, climatic conditions, diets
	C-4.3	Describes biological changes (growth, hormonal) during adolescence, and measures to ensure overall well-being
	C-4.4	Recognises and discusses substance abuse, viewing school as a safe space to raise these concerns

CG-5 Understands the interface of Science, Technology, and Society	C-5.1	Illustrates how Science and Technology can help to improve the quality of human life (health care, communication, transportation, food security, mitigation of climate change, judicious consumption of resources, applications of artificial satellites), as well as, some of the harmful uses of science in history
	C-5.2	Shares views on news and articles related to the impact that Science or Technology and society have on each other
CG-6 Explores the nature and processes of Science through engaging with the evolution of scientific knowledge and conducting scientific inquiry	C-6.1	Illustrates how scientific knowledge and ideas have changed over time (description of motion of objects and planets, spontaneous generation of life, number of planets) and identifies the scientific values that are inherent and common across the evolution of scientific knowledge (scientific temper, Science as a collective endeavour, conserving biodiversity and ecosystems)
	C-6.2	Formulates questions using scientific terminology (to identify possible causes for an event, patterns, or behaviour of objects) and collects data as evidence (through observation of the natural environment, design of simple experiments, or use of simple scientific instruments)
CG-7 Communicates questions, observations, and conclusions related to Science	C-7.1	Uses scientific vocabulary to communicate Science accurately in oral and written form, and through visual representation
	C-7.2	Designs and builds simple models to demonstrate scientific concepts
	C-7.3	Represents real world events and relationships through diagrams and simple mathematical representations
CG-8 Understands and appreciates the contribution of India through history and the present times to the overall field of Science, including the disciplines that constitute it	C-8.1	Knows and explains the significant contributions of India to all matters (concepts, explanations, methods) that are studied within the curriculum in an integrated manner
CG-9 Develops awareness of the most current discoveries, ideas, and frontiers in all areas of scientific knowledge in order to appreciate that Science is ever evolving and that there are still many unanswered questions	C-9.1	States concepts that represent the most current understanding of the matter being studied, ranging from mere familiarity to conceptual understanding of the matter as appropriate to the developmental stage of the students
	C-9.2	States questions related to matters in the curriculum for which current scientific understanding is well-recognised to be inadequate

4.4.1.2 Secondary Stage

CG-1 Explores the world of matter, its interactions, and properties at the atomic level	C-1.1	Describes classification of elements in the Periodic Table, and explains how compounds (including carbon compounds) are formed based on atomic structure (Bohr's model) and properties (valency)
	C-1.2	Investigates the nature and properties of chemical substances (distillation, crystallisation, chromatography, centrifugation, types and properties of mixtures, solutions, colloids, and suspensions)
	C-1.3	Describes and represents chemical interactions and changes using symbols and chemical equations (acid and base, metal, and non-metal, reversible, and irreversible)
CG-2 Explores the physical world around them, and understands scientific principles and laws based on observations and analysis	C-2.1	Applies Newton's laws to explain the effect of forces (change in state of motion: displacement and direction, velocity and acceleration, uniform circular motion, acceleration due to gravity) and analyses graphical and mathematical representations of motion in one dimension
	C-2.2	Explains the relationship between mass and weight using universal law of gravitation and connect it to laws of motion
	C-2.3	Manipulates the position of object and properties of lenses (focus, centre of curvature) to observe image characteristics and correspondence with a ray diagram, and extends this understanding to a combination of lenses (telescope, microscope)
	C-2.4	Manipulates and analyses different characteristics of the circuit (current, voltage, resistance) and mathematises their relationship (Ohm's law), and applies it to everyday usage (electricity bill, short circuit, safety measures)
	C-2.5	Defines work in scientific terms, and represents the relationship between potential and kinetic energy (conservation of energy) in mathematical expressions
	C-2.6	Demonstrates the principle of mechanical advantage by constructing simple machines (system of levers and pulleys)
	C-2.7	Describes the origin and properties of sound (wavelength, frequency, amplitude) and differences in what we hear as it propagates through different instruments

CG-3 Explores the structure and function of the living world at the cellular level	C-3.1	Explains the role of cellular components (nucleus, mitochondria, endoplasmic reticulum, vacuoles, chloroplast, cell wall), including the semi-permeability of cell membrane in making cell the structural basis of living organisms and functional basis of life processes
	C-3.2	Analyses similarities and differences in the life processes involved in nutrition (photosynthesis in plants; absorption of nutrients in fungi; digestion in animals), transport (transport of water in plants; circulation in animals), exchange of materials (respiration and excretion), and reproduction
	C-3.3	Describes mechanisms of heredity (in terms of DNA, genes, chromosomes) and variation (as changes in the sequence of DNA)
CG-4 Explores interconnectedness between organisms and their environment	C-4.1	Applies the knowledge of cellular diversity in organisms along with the ecological role organisms play (autotrophic or heterotrophic nutrition) to classify them into five-kingdoms
	C-4.2	Illustrates different levels of organisations of living organisms (from molecules to organisms)
	C-4.3	Analyses different levels of biological organisation from organisms to ecosystems and biomes along with interactions that take place at each level
	C-4.4	Analyses patterns of inheritance of traits in terms of Mendel's laws and its consequences at a population level (using models and/or simulations)
	C-4.5	Analyses evidences of biological evolution demonstrating the consequences of the process of natural selection in terms of changes: in allele frequency in population, structure, and function of organisms
CG-5 Draws linkages between scientific knowledge and knowledge across other curricular areas	C-5.1	Explores how literature and the arts have influenced Science
	C-5.2	Examines a case study related to the use of Science in human life from the perspective of Social Sciences and ethics (e.g., Marie Curie, Jenner, treatment of patients with mental illness, the story of the atomic bomb, green revolution and GMOs, conservation of biodiversity)
	C-5.3	Applies scientific principles to explain phenomena in other subjects (sound pitch, octave, and amplitude in music; use of muscles in dance form and sports)
CG-6 Understands and appreciates the contribution of India through history and the present times to the overall field of Science, including the disciplines that constitute it	C-6.1	Knows and explains the significant contributions of India to all matters (concepts, explanations, methods) that are studied within the curriculum in an integrated manner

CG-7 Develops awareness of the most current discoveries, ideas, and frontiers in all areas of scientific knowledge in order to appreciate that Science is ever evolving, and that there are still many unanswered questions	C-7.1	States concepts that represent the most current understanding of the matter being studied, ranging from mere familiarity to conceptual understanding of the matter as appropriate to the developmental stage of the students
	C-7.2	States questions related to matters in the curriculum for which current scientific understanding is well-recognised to be inadequate
CG-8 Explores the nature of Science by doing Science	C-8.1	Develops accurate and appropriate models (including geometric, mathematical, graphical) to represent real-life events and phenomena using scientific principles and use these models to manipulate variables and predict results
	C-8.2	Designs and implements a plan for scientific inquiry (formulates hypotheses, makes predictions, identifies variables, accurately uses scientific instruments, represents data, primary and secondary, in multiple modes, draws inferences based on data and understanding of scientific concepts, theories, laws, and principles, communicates findings using scientific terminology)

4.4.2 Essential Concepts

There is a general agreement that the processes of Science are equally important to learn as the concepts. But usually, this does not seem to get translated into our classrooms. There is a tendency to treat Science as merely a 'bunch of facts'. This approach assumes that there are certain concepts, theories, facts, and information that students must know, and once acquired, they have knowledge of Science. However, the knowledge base of Science known today is vast and continues to grow at an unprecedented rate. This implies that no matter how many 'facts of Science' we learn, it will never be enough.

The question that this throws up is, what are the essential concepts that students must learn in Science at the school level?

Even though it would be clear that this is not complete 'knowledge of Science', this 'essential set' could be decided based on the following criteria:

a. It provides adequate knowledge of the world for that age group.

b. It provides the base and platform for further learning of scientific ideas.

c. It provides adequate 'material' for developing the capacities and values related to Science Education.

d. It provides sufficient scope for inquiry and development of capacities for scientific inquiry.

In addition, whatever concepts are chosen, they should be interesting, challenging, and intelligible for young minds.

At the same time, students must develop capacities for scientific inquiry and the ability to communicate scientific questions and ideas aligned with each Stage. These are addressed in the Curricular Goals and Competencies for both the Middle and Secondary