National Curriculum for
GENERAL SCIENCE
GRADES IX-X
2009

GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD

TABLE OF CONTENT

Introduction

Our society is experiencing rapid and fundamental economic, social, and cultural changes that are drastically affecting our ways of life. We are also becoming aware of an increasing global interdependence and the need for sustainable environment, economy, and society. The emergence of a highly competitive and integrated international economy, rapid technological innovation, and a growing knowledge base will continue to have a profound impact on people's lives. Advancements in science and technology are playing an increasingly significant role in everyday life. Therefore, science education will be a key element in developing scientific literacy and in building a strong future for Pakistan's young generation.

Learning in science is fundamental to understanding the world in which we live and work. It helps people to clarify ideas, to ask questions, to test explanations through measurement and observation, and to use their findings to establish the worth of an idea. Science is not seen as merely objective and value free but is recognized as being part of human experience. As such it is an integral part of daily life and relevant to everyone.

Science, technology, and society are responsive to each other. While science may act as a catalyst for change, it is also influenced by technological advances and social and economic pressures. The applications of science affect our environment and the way we live our lives.

Consistent with the National Education Policy and views expressed in a variety of national and international science education documents; conferences, seminars and workshops on education; and by various experienced science educators of Pakistan, the following goals for the school science education in Pakistan have been determined:

- *Encourage students at all grade levels to develop a critical sense for wonder and curiosity about scientific and technological endeavors;*
- *Enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and lives of others;*
- *Prepare students to critically address social, economic, ethical, and environmental issues related to science and technology;*
- *Provide students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study, prepares them for science-related*

occupations, and engages them in science-related activities appropriate to their interests and abilities; and

- *Develop in students, of varying aptitudes and interests, and the knowledge of wide variety of careers related to science, technology, and the environment.*

The above goals may be summed in the form of the National Vision for School Education which intends to develop scientific literacy by acquiring science-related Knowledge, Skills and Attitudes, and emphasizes that this is best done through the study and analysis of the interrelationship among Science, Technology, Society and Environment (STSE).

Curriculum Focus

2.1 Inquiry-based Curriculum

Science is a systematic process of inquiry about natural phenomena. It is through this systematic process of inquiry that the content of scientific knowledge is derived. When science is taught as a process of inquiry, students learn how to be scientists. When students use inquiry to discover substance, they not only learn a great variety of facts and concepts, but they also learn how these are related to each other, and how it is that we human beings come to understand our world and adjoin to the great body of information we call *knowledge*.

Therefore this General Science Curriculum, which strives for scientific literacy, is intended to engage students in ***Scientific Inquiry,*** the ***Problem Solving*** process, and in ***Decision Making***.

2.2 The Student-centered Curriculum

Science and technology are major influences in many aspects of our daily lives, at work, at play, and at home. Therefore quality learning in science has been/must be promoted uniformly at national level, by focusing on all students irrespective of their gender and socio-economic & cultural diversity, living in urban or rural areas of Pakistan so as to cohesively satisfy their current needs and expectations of the future.

The General Science Curriculum has been made much student-oriented and for this purpose, well-defined **General Curriculum Outcomes (Learning Strands), Content Standards, Key Stage Curriculum Outcomes (Benchmarks)**, and **Specific Curriculum Outcomes (Student Learning Outcomes – SLOs)** have been developed so that all students should be:

- Knowledgeable about the important concepts and theories of the three major branches of scientific study: Earth and space, life, and physical sciences;
- Able to develop an understanding of the world, built on current scientific theories;
- Able to learn that science involves particular processes and ways of developing and organizing knowledge and that these continue to evolve;
- Able to think scientifically and use their current scientific knowledge and skills for problem solving and developing further knowledge;

- Able to use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment;
- Able to construct new knowledge for themselves through reading, discussion, and science learning activities;
- Familiar with the natural world, and respectful of its unity, diversity, and fragility; and
- Able to reflect in an informed way concerning the role of science in human lives.

2.3 An Outcomes-focused Curriculum

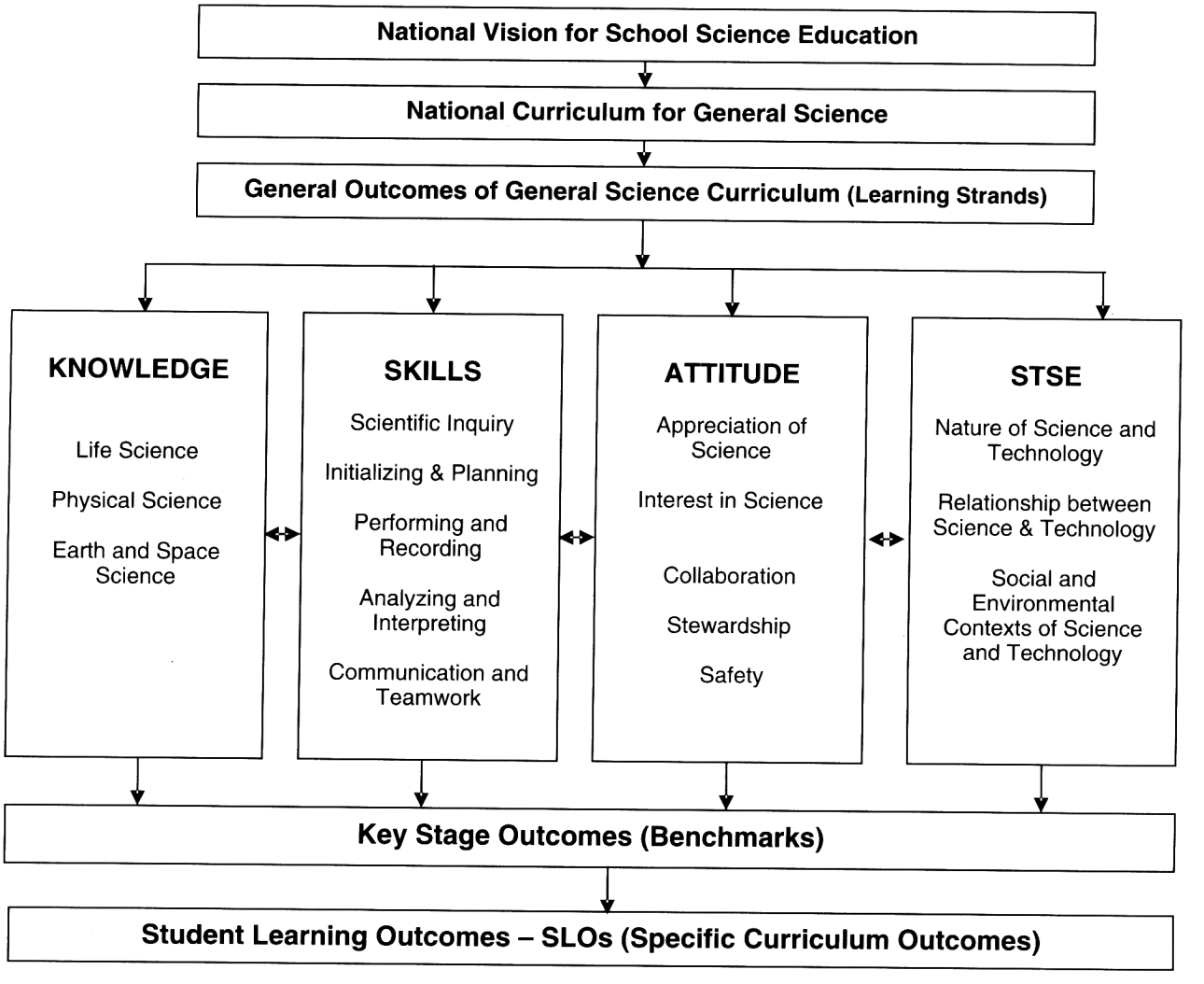
This General Science Curriculum is an Outcomes-Focused framework for the school science education and intended to:

1. Specify a set of well-defined outcomes in the form of General Curriculum Outcomes (Learning Strands), Content Standards, Key-stage Curriculum Outcomes (Benchmarks) and Specific Curriculum Outcomes (Student Learning Outcomes) that have been presented hereunder, for both students and teachers to achieve;
2. Provide a basis for study programmes that will challenge all students and offers all students opportunities to achieve these outcomes;
3. Recognize and value the different knowledge and experience of different students; and
4. Take into account the diversity among children and young adults in Pakistan: in terms of gender, culture, learning capacity, socio-economic background, and geographic location.

However, a small number of students with specific physical and/or intellectual disabilities may not be able to participate fully in the learning activities and programmes to achieve certain outcomes in this curriculum document.

2.4 The Conceptual Map for the Curriculum Outcomes

The conceptual map below provides the blueprint of the learning strands, benchmarks and learning outcomes.



The Selection of:

Learning Strands, Content Standards, Benchmarks & Student Learning Outcomes (SLOs)

LEARNING STRANDS (General Curriculum Outcomes)

Curriculum Outcomes or Learning Strands are statements articulating what students are expected to know and be able to do in particular subject areas. These outcomes statements also describe what knowledge; skills and attitudes students are expected to demonstrate at the end of certain key stages in their education as a result of their cumulative learning experiences at each grade level in the school entry to the school graduation continuum.

In this General Science curriculum, following six (6) learning strands have been selected for the students of Grades IX - X:

1. Life Science,
2. Physical Science, and
3. Earth and Space Science.

These are called the Contextual Strands, which will cover the first part of the General Curriculum Outcomes, i.e., Knowledge. Other major learning areas are:

4. Skills,
5. Attitudes, and
6. Science, Technology, Society and Environment (STSE).

These are called the Integrating Strands.

Strands 4, 5, and 6 (Skills, Attitudes, and Science, Technology, Society, and Environment) contain the processes desired of students and must, therefore, be reflected in all science disciplines. These strands are designed to be explicitly taught and embedded within each of the content strands 1, 2, and 3, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to "umbrella" and complement the content of Life Science, Physical Science, and Earth & Space Science.

CONTENT STANDARDS

Standards are basically the descriptive statements of the Strands. *Standards outline what students should know and be able to do and value all through learning in Science.* In other words, Curriculum standards are broad, descriptive and qualitative statements which

represent a set of expectations about what all students should know, be able to do and the values/attitudes they should hold at the end of the learning cycle.

BENCHMARKS (Key Stage Curriculum Outcomes)

Benchmarks are the statements that identify the learning outcomes of students what they are expected to know, be able to do, and value by the end of, for example, Grades V, VIII, X and XII as a result of their Grade-wise cumulative learning experiences.

In Science curriculum each standard is followed by a set of benchmarks at these developmental levels with regard to the themes. Benchmarks establish what students are expected to know, be able to do and the dispositions/values they should develop at various developmental levels such as primary, middle, secondary and higher secondary school.

In this curriculum one set of Benchmarks has been selected which is for the grade-cluster of IX and X - what learning outcome are expected from all students at the end of Grade-X in the six (6) Learning Strands (Life Science, Physical Science, Earth & Space Science, Skills, Attitudes and STSE).

These Benchmarks are intended for all students. However it is acknowledged that different students will achieve these Benchmarks in different ways and to different depth and breadth depending on interest, ability, and context.

Also at the same time, the selected Benchmarks will present opportunities and challenges for teachers to be able to help their students in achieving the desired learning outcomes at the end of Grade X.

Student Learning Outcomes – SLOs (Specific Curriculum Outcomes)

This Curriculum further identifies the Student Learning Outcomes for the attainment of the Benchmarks and Standards.

Student Learning Outcomes are the learning statements, specifically describing what students are supposed to learn and able to do at each Grade level in order to achieve the specified Benchmarks for every Grade-Cluster. In other words, SLOs are the incremental steps toward accomplishment of Benchmarks, which are organized around the Standards and listed for each grade level as students advance in their knowledge, skills, attitudes, and applications.

Therefore well-defined SLOs for the Grades IX and X have been provided in this document, which reflect the expected learning outcomes towards achieving the required Benchmarks for grades IX - X for the six (6) learning strands.

Learning Strands, Content Standards, and Benchmarks

STRAND-1: LIFE SCIENCE

Rationale

The Life Science strand focuses on to understand and explain the nature of life. The purpose is to expand students' understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptations and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

At the end of grade X, students will be able to develop the ability to use appropriate vocabulary and scientific terminology related to the life sciences to communicate clearly.

Content Standard:

Students will be able to understand, explain and differentiate between the structure, characteristics and basic needs of living things, the processes of life, and will also investigate the diversity of life and how living things interact with each other and their environment.

Benchmarks

By the end of Grade X, students will be able to:

1. Analyze the various aspects of health and healthy life style.
2. Explain the causes, effects and preventive measures of different disorders and diseases.
3. Describe the importance of cell, cell types, and cellular processes.
4. Explain the genetic mechanisms and molecular basis of inheritance.
5. Analyze the relationships among various organisms and their environment.
6. Explain the structure and function of ecosystems and relate how ecosystems change over time.
7. Describe the role of energy within living systems.

8. Identify technologies used in agriculture, medical diagnostics and treatments, and improving the quality and carrying capacity of environment.
9. Analyze the global environmental issues and evaluate the environmental management strategies which are in practice.

STRAND-2: PHYSICAL SCIENCE

Rationale

This strand focuses on students' understanding of matter and its transformations, energy and its transformations, and the motion of things. Students will increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

In all grades, students will develop the ability to use appropriate vocabulary related to physical world to communicate clearly about scientific and technological concepts.

Content Standard

Students will analyze (quantitatively and qualitatively) the structures, properties, forms, and patterns in matter and energy, predict changes and interactions, and evaluate theories and structures using knowledge of chemistry and physics.

Benchmarks

By the end of Grade X, students will be able to:

1. Relate the properties of chemicals with their usage, effects on our lives, the technologies depended, and the careers associated with them.
2. Identify the chemical reactions, their ingredients used in the production of the common consumer products.
3. Explain the impact of chemicals on the individuals and environment and suggest solutions to problems they create.
4. Identify the water and energy resources and discuss their importance for the development of a country.
5. Analyze the availability of water and energy resources, their current utilization and conservation practices and their future requirements in Pakistan.
6. Design a plan for the development, protection and management of new water and energy resources.
7. Explain the characteristics, effects and uses of static electricity in our daily life.
8. Examine the social, economic and environmental costs and benefits of the methods of electrical energy production in Pakistan.

STRAND-3: EARTH AND SPACE SCIENCE

Rationale

Earth and space science provides foundation for students to develop an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic theories, and models that explain the world by studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

Content Standard

Students will understand and explain the structure, processes, and interactions among the Earth's systems. They will also explain scientific theories about the origin and evolution of the Earth and the universe, and investigate how we learn about the universe.

Benchmarks

By the end of Grade X, students will be able to:

1. Analyze the factors used to explain the history and evolution of the Earth and the Universe.
2. Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.
3. Explain the relationships between the Earth's land masses, oceans, and atmosphere.
4. Identify the technologies used in industries and space exploration.
5. Evaluate that space exploration is an active area of scientific and technological research and development.

STRAND-4: SKILLS

Rationale

Inquiry process establishes the basis for students' learning in science. Students use scientific processes: questioning, planning and conducting investigations using appropriate tools and techniques to gather data, thinking logically and critically about the relationships between evidence and explanation and communicating results.

Content Standard

Students will develop the skills required for scientific inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions, and for reflecting on scientific knowledge and its application.

Benchmarks

By the end of Grade X, students will be able to:

1. Generate questions, conduct investigations, and developing solutions to real-life problems through reasoning and observation.
2. Analyze and present findings that lead to future questions, research, and investigations.
3. Reflect on scientific knowledge and its application to new situations to better understand the role of science in society and technology.
4. Work collaboratively to carryout science-related activities and communicate ideas, procedures and results.

STRAND-5: ATTITUDES

Rationale

This strand refers to the students' need for developing the attitudes that are considered essential for a meaningful study of science and its relationship to the society. These include: a commitment to the pursuit of knowledge and achievement of potential, resulting in a disposition towards striving to understand the world and how best one can make a positive contribution towards it; respect and concern for others and their rights, resulting in sensitivity to and concern for the well-being of others; social and civic responsibility, resulting in a commitment to exploring and promoting the common goal; and environmental responsibility, resulting in a respect and concern for the natural and cultural environment and a commitment to regenerative and sustainable resource use.

Content Standard

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge for the mutual benefit of self, society, and the environment.

Benchmarks

By the end of Grade X, students will be able to:

1. Show a continuing curiosity and interest in a broad scope of science related field of issues.
2. Confidently pursue further investigations and readings.
3. Consider many career possibilities in science and technology-related fields.
4. Appreciate the role and contribution of science and technology in our understanding of the world.
5. Value accuracy, precision and honesty.

6. Appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds.
7. Realize that the applications of science and technology can have both intended and unintended effects.
8. Persist in seeking answer to difficult questions and solutions to difficult problems.

STRAND-6: SCIENCE, TECHNOLOGY, SOCIETY, AND THE ENVIRONMENT (STSE)

Rationale

Scientific investigation groups from the contributions of many people. History & Nature of Science (NOS) emphasizes the importance of historical perspective and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science, the role that scientists play in the development of various cultures, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

Content Standard

Students will develop an understanding of the nature of science and technology, the relationship between science and technology and of the social and environmental context of science and technology.

Benchmarks

By the end of Grade X, students will be able to:

1. Identify individual, cultural, and technological contributions to scientific knowledge.
2. Recognize that science is a process for generating knowledge.
3. Describe and explain the role of collecting evidence, finding relationships, proposing explanations and imagination in the development of scientific knowledge.
4. Provide examples of scientific knowledge that have resulted in the development of technologies.
5. Describe applications of science and technology that have developed in response to human and environmental needs.
6. Describe positive and negative effects that result from applications of science and technology in their own lives, the lives of others, and the environment.

7. Develop viable solutions to a need or problem.
8. Describe how people use science and technology in their professions.
9. Explain the importance of choosing words that are scientifically or technologically appropriate.
10. Explain the importance of using appropriate language in science or technology.

5 Learning Contents and Student Learning Outcomes

GRADE – IX

Contents	Student Learning Outcomes
UNIT 1: **HISTORY AND NATURE OF SCIENCE** • Nature of Science • History of Science as a Human Endeavour (Individual, Cultural, and Technological Contributions to Scientific Knowledge) • Science and Islam • Disciplines of Science • Limitations of Science	**Understanding** The students will be able to: • Define science and describe how the nature of science makes it different from other modes of knowing. • Describe how human curiosity and needs have influenced science, impacting the quality of life world wide. • Describe the contributions of some eminent Muslim scientists (Jabar Bin Hayyan, Muhammad Bin Zikrya Al-Razi, Abni-ul-Haitham, Al-Bairuni and Bu Ali Sina) in science. • Describe how various people and cultures in past and present have made important contributions to scientific innovations. **Skills and Attitude** The students will be able to: • Analyze the specific changes in science that have affected society. • Analyze the specific cultural and societal issues that promote or hinder scientific advancements.

Contents	Student Learning Outcomes
	Understanding The students will be able to: • Explain the process by which accepted ideas are challenged or extended by scientific innovation. • Distinguish between pure and applied science. • Explain how Islam supports the acquisition of scientific knowledge. • Explain the relationship between different branches of science. • Describe the limitations of science.
UNIT 2: **CHEMISTRY AND LIFE** • Common elements and compounds and their physical and chemical properties • Chemical composition of common materials used in our daily life • Impact of production of chemical products on our lives and environment • Chemical change in the events that we encounter daily • The recycling of elements and chemical compounds	**Understanding** The students will be able to: • Identify the chemical composition of common materials such as plastic, polyester, nylon, polythene, rubber, glass, sugar, table salt, washing powder. • Compare the physical and chemical properties of elements and compounds to assess their potential uses and associated risks (e.g., hydrogen versus helium in balloons, copper versus aluminum in wiring, copper versus lead in plumbing, water and alcohol in thermometers, petrol and diesel in automobiles) **Skill and Attitude** The students will be able to: • Investigate how the production of chemical products (aerosol, CFCs, fertilizers, pesticides) has an impact on our lives and environment. • Find examples of chemical changes in the events that we encounter daily (burning,

Contents	Student Learning Outcomes
	rusting, fermentation, respiration and decaying). **Understanding** The students will be able to: • Describe the recycling of elements and compounds (Cu, Fe, Al, plastic, glass and rubber) and its benefits. **Skill and Attitude** The students will be able to: • Investigate potential careers associated with an understanding of the physical and chemical properties of elements and compounds.

UNIT 3:
HEALTH, DISEASES & PREVENTION
• Health
  • Natural food products, processed food, fast and junk food
  • Malnutrition, under nutrition, overeating, obesity
  • Cleanliness
  • Abuses of drugs & smoking
  • Sleep and rest
  • Physical fitness / Importance of exercise
• Disorders and diseases
  • Dietary disorders
  • Blood and its Diseases
  • Human immune mechanism and HIV - AIDS
  • Diseases caused by germs.
  • Viral: Small pox, Polio,
	Understanding
	The students will be able to:
	• Explain the relationship among dietary intake, eating behaviours, physical activity, and emotional health.
	• Explain the cleanliness and its importance for health.
	• Briefly describe the composition of blood and mention the causes and effects of important blood diseases like leukemia, hemophilia and anemia.
	• Describe the viral, bacterial and fungal infections and parasitic diseases (mentioned in the themes) in terms of their causes, signs and symptoms, preventions and treatments.
	• Relate HIV with the human immune system and describe the ways to cope with the spread of this disease.
	Skills and Attitude

Contents	Student Learning Outcomes
Measles & Hepatitis • Bacterial: Tuberculosis, Whooping Cough, Diphtheria, Tetanus, Typhoid & Cholera • Fungal: Ring Worm • Parasitic: Malaria, Threadworms, *Ascaris* • Research and medical advances in Diseases Control • Spreading of germs and their sources • Prevention and cure (vaccination, antibiotic etc.) • Emergency and First-Aid	The students will be able to: • Research the relationship of strokes to the following risk factors: obesity, high-fat diets and smoking. • Collect and interpret local, national, and international statistics on a specific disease spread by germs. • Design and evaluate a personal action plan for good health and nutrition. • Analyze ways in which research and medical advances have changed the process which help to prevent, diagnose, monitor, and/or treat specific diseases and their spread. **Understanding** The students will be able to: • Describe the first aid of dog bites, snake bites, insect bites, and artificial respiration and role play the same situations for the first aid.
UNIT 4: **POPULATION AND ENVIRONMENT** • Growth of human population • Rate of human population growth in Pakistan and neighboring countries • The impacts of human overpopulation on environment • Relationship between overpopulation and sustainable development	**Skills and Attitude** The students will be able to: • Assess how the size and the rate of growth of human population are determined by birth rate, death rate, immigration, emigration, urbanization and carrying capacity of the environment. **Understanding** The students will be able to: • Describe the rate of human population growth in Pakistan and neighboring countries. • Explain the impacts of overpopulation on

Contents	Student Learning Outcomes
	the environment. • Describe how overpopulation is the major hindrance in the sustainable development of any region.
UNIT 5: **ENERGY SOURCES** • Energy sources and their significance • Measurement of energy (Natural gas and electricity) • Energy consumption & conservation • Energy demands in the world as well as in Pakistan • Energy and the environment; nuclear fuel hazards – remedial measures • Resource Protection and Management	**Understanding** The students will be able to: • Describe energy sources (fossil fuels, hydrogen as fuel, nuclear energy, hydal, wind and solar energy). • Explain: ○ Conventional and non-conventional energy sources. ○ Renewable and non renewable energy sources. ○ Measurement of energy (natural gas and electricity) • Identify the role energy sources play in the development of a country. • Recognize that limited energy sources are available to Pakistan. • Critically reflect on nuclear energy usage in the world and its impact on the life on Earth. • Compare the annual production of fossil fuels and alternate fuels in Pakistan with their consumption. **Skills and Attitude** The students will be able to: • Evaluate the ways of conservation and effective utilization of the available energy sources in Pakistan.

Contents	Student Learning Outcomes
	Understanding The students will be able to: • Describe thermal pollution, fossil and nuclear pollution and fuel hazards. **Skills and Attitude** The students will be able to: • Analyze various factors existing around in their surroundings leading to thermal pollution, fossil fuel pollution and nuclear fuel hazards and suggest remedial measures to overcome it. • Suggest various methods of energy source protection and management and suggest a plan for Pakistan.

GRADE – X

Learning Themes and Student Learning Outcomes

Contents	Student Learning Outcomes
UNIT 6: **ELECTRICITY IN EVERYDAY LIFE** • Static charges, their characteristics and effects • Electrical circuits used in everyday life • Practical uses of static and current electricity, and their impact on everyday life • Safety measures • Social, economic, and environmental costs and benefits of the methods of electrical energy production used in Pakistan	**Understanding** The students will be able to: • Describe the characteristics and effects of static charges. • Explain static charges in terms of electron transfer. • Explain practical applications of static and current electricity (e.g., household appliances) • Identify problems related to electrostatic charge in everyday situations and evaluate solutions (e.g., use of an electrostatic paint sprayer for uniform paint; use of static straps to reduce charge build-up in automobiles; Use of electrostatic precipitators to decrease pollution; use of lightning rods to protect buildings. • Describe household wiring and its typical components (e.g., parallel circuits with switches, fuses, circuit breakers, outlets) **Skills and Attitude** The students will be able to: • Develop a solution to a practical problem related to the use of electricity in home, school, or community (e.g., choose an appropriate fuse or circuit breaker for a specific circuit). • Propose a plan for a self-contained system to generate energy, using renewable energy resources, to meet the energy requirements of a dwelling, farm, or

Contents	Student Learning Outcomes
	community in Pakistan. • Identify the safety measures to avoid and handle electric hazards. **Understanding** The students will be able to: • Describe careers that involve electrical technologies, and use print and electronic media to identify the knowledge and skill requirements of such careers.
UNIT 7: **CHEMICAL REACTIONS AND THEIR PRACTICAL APPLICATIONS** • Chemical reactions in everyday life and their practical applications • Chemical reactions in technological products and processes • Methods for the disposal of waste chemicals	**Understanding** The students will be able to: • Recognize those characteristics which indicate that a chemical reaction has taken place. **Skills and Attitude** The students will be able to: • Use scientific nomenclature to identify common consumer products (e.g., identify ingredients in food products or cosmetics from the labels). • Investigate applications of acid-base reactions in common products and processes (e.g., prepare soap from oil and sodium hydroxide and compare its lather formation with that of commercial soaps). • Relate chemical reactions to familiar processes encountered in everyday life (e.g., reactions in film processing, food processing, fabric and hair dyeing, agriculture, pulp-and-paper and mineral processing) and identify careers that require knowledge of such processes. • Research the methods, impact and safety consequences of chemical disposal in

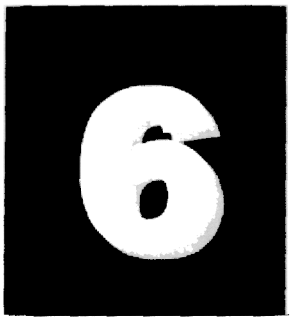
Contents	Student Learning Outcomes
	Pakistan, and recommend appropriate disposal methods (e.g., dumping car batteries, tyres, plastics, paints, or metals in landfill sites).
UNIT 8: **BIOTECHNOLOGY** • Nucleus & hereditary material (Chromosomes, genes, RNA, DNA) • Cell division (Mitosis and Meiosis) • Transfer of genetic information and DNA replication • Genetic disorders, e.g. Thalasemia, sickle cell anemia, and down syndrome) • Genetic Engineering and Biotechnology • Cloning, transgenic plants & animals • Application of Bio-Technology & Genetic Engineering (Agriculture, forensic, livestock and dairy products, food processing, pharmaceutical)	**Understanding** The students will be able to: • Describe the structure and function of nucleus and importance of hereditary material (Chromosomes, genes, RNA, DNA) found in it. • Identify the relationships among nucleic acids (DNA and RNA), genes and chromosomes. • Describe the molecular basis of heredity including DNA replication. • Describe the purposes and processes of cellular reproduction. • Explain the common genetic disorders. **Skills and Attitude** The students will be able to: • Analyze the role of genetic engineering and biotechnology in the present world. • Investigate careers that require an understanding of reproductive biology.
UNIT 9: **WATER RESOURCES** • Forms of water (Oceans, seas, lakes, rivers, springs, glaciers, underground water) • Fresh water resources; particularly in Pakistan • Utilization of water resources in	**Understanding** The students will be able to: • Recognize the various forms of water available on Earth. • Identify the amount of fresh water available on Earth with an emphasis on Pakistan. • Describe the existing ways of utilization of water resources in Pakistan and explain the

Contents	Student Learning Outcomes
Pakistan and emerging issues • Growing demand for water resources • Threats to water resources • Sustainable development of water resources, e.g. potable water system	issues and problems Pakistan is facing in utilizing the water resources effectively for its people. • Identify methods of reclamation and conservation of water. • Explain the water resources are facing serious threats such as pollution, climate change, urban growth and landscape changes (deforestation) that are mainly caused by human activity. • Describe the implication of the growing demand of water in the world. **Skills and Attitude** The students will be able to: • Suggest ideas for the sustainable development of water resources in Pakistan.
UNIT 10: **ENVIRONMENTAL PROBLEMS AND MANAGEMENT** • Regional and global environmental problems and Natural Disasters • Legislation or Laws on air pollution, water pollution, noise pollution, drinking water quality, toxic substances, and coastal zones • Control strategies for treating air and water pollutants • Protection at individual level (Excessive use of TV, Mobiles, computer, etc.)	**Understanding** The students will be able to: • Identify the regional and global environmental problems such as ozone depletion, global warming, acid rain, greenhouse effect, desertification and climate change, solid and hazardous wastes. • Describe the natural disasters caused by earthquakes, storms including El-Nino and La-Nina. • Identify the legislation or laws on environmental problems such as ozone depletion, global warming, air pollution, water pollution, drinking water quality, and toxic substances. • Describe the control strategies that can be

Contents	Student Learning Outcomes
	used for treating air and water pollutants. • Describe the harmful effects of the excessive use of TV, Mobiles, computer on individuals' health.
UNIT 11: **SCIENCE, TECHNOLOGY AND DEVELOPMENT** • Important Technological Developments a. Types, functions and uses of Lasers b. Optical fiber system c. Modern methods of medical diagnostic and treatments (Ultra-sonography, CT Scan, X-Rays, MRI, ECG, EEG, radiography, radiotherapy, chemotherapy, angiography) d. Information technology (Computer Telephone, fax, computer, TV, radio, mobiles) e. SUPARCO	**Understanding** The students will be able to: • Describe the principle of lasers and optical fiber system, and describe their functions and uses in different fields with examples. • Describe the functions and uses of X-rays, Ultrasound, ECG, EEG, MRI, CT-Scan, angiographies. • Describe the technologies such as computer telephone, fax, computer, TV, radio, mobiles used in the modern information age • Explain the contribution SUPARCO has made in the development of our country and list their future plans.

Estimated Weightage and Time Allocation (IX-X)

Unit	Content	Weightage in %age	Number of Periods
1.	History and Nature of Science	6	20
2.	Chemistry and Life	12	40
3.	Health, Diseases ands Preventions	12	40
4.	Population and Environment	10	40
5.	Energy Sources	10	40
6.	Electricity in Everyday Life	8	25
7.	Chemical Reactions and their Practical Applications	8	25
8.	Biotechnology	10	40
9.	Water Resources	6	20
10.	Environmental Problems and Management	9	35
11.	Science, Technology and Development	9	35



Teaching and Learning

6.1 The Role of Teachers

Teacher has highly important responsibilities in implementing vital trends in the Curriculum. Implementing the curriculum means that when teachers design and develop learning and teaching strategies to suit the needs of their students, they must ensure that these strategies include learning opportunities and enriching experiences for their students aimed at achieving the Learning Outcomes set out in the Curriculum.

What students learn is fundamentally connected to how they learn it. Therefore there is a need for such forms of classroom organization and instructional strategies where the teacher is a facilitator of learning whose major tasks include:

- Creating a classroom environment that reflects a constructive, active view of the learning process and supports the learning and teaching.
- Designing effective learning experiences that help students achieve expected Learning Outcomes.
- Stimulating and managing classroom discourse in support of student learning.
- Learning about and then using student's motivations, interests, abilities, and learning styles to improve learning and teaching.
- Selecting teaching strategies from a wide repertoire, including the locally available resources.
- Assessing students' learning and activities involved, and the learning environment to make ongoing instructional decisions.

6.2 The Changing Nature of Teaching and Learning

Traditional Instructional Practices generally have shown that;

- Classrooms appear to be dominated by textbooks and short-answer activity sheets.
- Teachers use the same set of practices for every lesson. They do not review the previous day's lessons, state their objectives, present, demonstrate, model, check for understanding, provide guided practice, and use closure.
- The majority of classroom time is spent on teachers lecturing, students listening, students reading textbooks, or students filling out worksheets.

- Fewer connections between school learning and the everyday world exist.
- Knowledge of subject becomes an exercise in naming and memorizing.

In such an environment, the role of the student is to memorize information, conduct well-regulated experiments, and performs activities using a specific prescribed procedure and is then tested on their ability to repeat these tasks or remember specific facts.

Science education is a key element in developing scientific literacy and in building a strong future for young people. This vision of science education, calls for a shift in the focus of teaching and learning context. To achieve the goal for science education mentioned in this curriculum there is a need to:

- Encourage students at all grade levels to develop a critical sense for wonder and curiosity about scientific and technological endeavors;
- Enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives ands lives of others;
- Prepare students to address critically science related societal, economic, and environmental issues and
- Develop an understanding of the interconnections among science, technology and society and the environment.

6.3 Promoting Scientific Literacy in Teaching and Learning Process

Being scientifically literate requires that a person have essential understanding of key science ideas, along with a fluency in the language and terms used to describe them.

Scientific literacy requires the ability to apply critical thinking skills when dealing with science-related issues. The science curriculum gives special attention to the age-appropriate critical thinking, or inquiry skills that are presented as learning outcomes of each of the content standards. Further, in limiting the number of content standards required to be taught, the curriculum encourages the implementation of a hands-on/minds-on science programme in which students and teachers have time for in-depth explorations that build understanding of the way in which scientific knowledge is created, validated and communicated.

This will provide opportunity to students not only to understand science principles but to relate these to personal, social and global issues and technologies rather than the traditional organization around life, physical and Earth sciences.

Acquiring these students will become confident and capable lifelong learners, equipped with the skills needed to access, understand, evaluate and apply information in various contexts.

Scientific knowledge should be constructed through a hands-on/minds-on approach with overarching concepts that connect the sciences and other disciplines. Methodology and teaching strategies should be inquiry-based and include hands-on/minds-on activities

Teaching for conceptual change calls for knowing the preconceptions that students bring to the classroom and purposefully designing, intellectually engaging explorations that encourage students to confront and refine their own ideas. The teaching strategies described in this Curriculum are intended to support these changing emphases for classroom learning.

6.4 Teaching and Learning Strategies

The teaching of science should be aimed at developing a scientific attitude in children rather than providing mere information. This can be achieved if teachers emphasize understanding of concepts, development of independent thinking and investigation skills, arousing curiosity to know more and interact with everyday situations to apply knowledge.

Science Inquiry

Inquiry is the process of finding answers to questions. The skills of science inquiry include asking questions, proposing ideas, observing, experimenting, and interpreting the evidence that is gathered. Observation and evidence are key elements.

An inquiry may be initiated in a variety of ways. It may be based on a question brought to the classroom by a teacher or student; or it may arise out of an activity, an interesting observation, an unexplained event or a pattern that appears worth pursuing. Engagement in inquiry is not a linear process; it can have a variety of starting points, and the steps followed may vary from one inquiry activity to another. When an unexpected observation is made or a procedure does not work, there is opportunity for new ideas to emerge and a new set of procedures to be followed. -

Teaching Students to Conduct an Inquiry Investigation

An inquiry Classroom is one where students take responsibility for their learning and are required to be active participants, searching for knowledge, thinking critically and solving problems. Inquiry develops students' knowledge of the topic of investigation inquiry, skills of questioning, hypothesizing, information gathering, critical thinking and presentation.

There are two main types of inquiry: ***knowledge-based inquiry and problem-based inquiry/investigation.*** Knowledge-based inquiry enables students to enhance their knowledge and understanding of content. Problem-based inquiry/investigation encourages study of social and scientific problems.

Steps in an Inquiry / Investigation

1. Observe and Ask Questions

- Use your senses to make observations and ask questions.
- Record one question that you would like to answer.
- Write down what you already know about the topic of your question.

- Decide what other information you need.
- Do research to find more information about your topic.

2. Form a Hypothesis

- Write a possible answer to your question. A possible answer to a question that can be tested is a hypothesis.
- Write your hypothesis in a complete sentence.

3. Plan an Experiment/Investigation

- Decide how to conduct a fair test of your hypothesis by controlling variables. (Variables are factors that can affect the outcome of the investigation).
- Write down the steps you will follow to do your test.
- List the equipment or resources you will need.
- Decide how you will gather and record your data

4. Conduct the Experiment

- Follow the steps you wrote.
- Observe and measure carefully.
- Record everything that happens.
- Organize your data so you can study it carefully.

5. Draw Conclusions and Communicate Results

- Analyze and interpret the data you gathered.
- Make charts, tables, or graphs to show your data.
- Write a conclusion. Describe the evidence you used to determine whether your test supported your hypothesis was correct.

6. Investigate Further

- ***What if your hypothesis was correct...***

  You may want to pose another question about your topic that you can test.

- ***What if your hypothesis was incorrect...***

  You may want to form another hypothesis and do a test on a different variable.

Teaching Students Problem-Based Learning

Problem-based learning (PBL) is an exciting way to learn science. It engages students in solving problems, and reinforcing learning. A problem-based learning environment develops self-directed learners. This is preferable to a learning environment in which students only watch, memorize, and repeat what they have been told.

Method for Students

Effective problem-solving requires an orderly approach. Problem-solving skills do not magically appear in students as a result of instructor simply throwing problems at them.

The steps of a problem solving process are Define, Explore, Narrow and Test.

1) ***Define*** *the Problem Carefully*

What exactly are you trying to solve or determine? Does the problem have several components? If several, state them separately.

2) ***Explore*** *Possible Solutions*

Brainstorm ideas that may contribute to a solution. Justify and clarify your ideas.

3) ***Narrow*** *Your Choices*

After developing a list of hypotheses, sort them, weed them, and rank them. List the type of information required to test each hypothesis. Give priority to the simplest solution.

4) ***Test*** *Your Solution*

Now test your solution. If it does not work then try out other solutions. If all your possible solutions are eliminated, begin the cycle again: define, explore, narrow, and test.

Attitudes and Values in the Classroom

Attitudes refer to generalized aspects of behaviour that are modeled for students by example and reinforced by selective approval. Attitudes are not acquired in the same way as skills and knowledge. However during the classroom learning experiences science education can contribute to attitudinal growth when students are:

- Involved in science investigation and activities that stimulate their interest and curiosity, thus increasing their motivation for learning and encouraging them to become interested in preparing for potential science- related careers of furthering other science-related interests;
- Provided to opportunities for development, reinforcement, and extension of attitudes that support scientific inquiry such as open- mindedness and respect for evidence, initiative and perseverance, and creativity and inventiveness;
- Provided with opportunities to work in groups' situations and on real-life problems, thus developing a sense of interpersonal responsibilities, openness to diversity, respect for multiple perspectives, and an appreciation of the efforts and contributions of others;

- Involved in activities that encourage responsible action toward living things and the environment, and when students are encouraged to consider issues related to sustainability from a variety of perspectives; and
- Encouraged to assess and manage potential dangers and apply safety procedures, thus developing a positive attitude towards safety.

Therefore, teaching methods and learning activities that encourage students to recognize the value and relevance of what they are learning, will go a long way towards motivating students to work and to learn effectively.

The Importance of Safety

Teachers are responsible for ensuring the safety of students during classroom and outside classroom activities and also for encouraging and motivating students to assume responsibility for safety. They must also teach students the knowledge and skills needed for safe participation in science activities. For these reasons, teachers must model safe practices at all times and communicate safety expectations to students

To carry out their responsibilities with regard to safety, it is important not only that teachers have concern for their own safety and that of their students, but also that they have:

- Knowledge necessary to use the materials, tools, and procedures involved in science safely;
- Knowledge concerning the care of living things – plants and animals – that are brought into the classroom; and
- Skills needed to perform tasks efficiently and safely.

The Affective Teacher

Children are more likely to imitate behaviours and attitudes that they perceive as pleasurable and beneficial. Thus, children's attitudes are greatly shaped by how a teacher engages in the science process. It is the responsibility of the teacher to model the affective realm of curiosity, excitement and enjoyment, as well as a desire to know. Teacher's feelings of wonder and joy will, in turn, generate interest in the scientific process of discovery.

Homework

Homework is an essential component of the science programme as it extends the opportunity for students to think scientifically and to reflect ideas explored during Class time. Meaningful and positive homework experiences can

- Contribute to personal growth, self- discipline, and learning responsibility
- Reinforce the ideas and processes students have learned or developed at school
- Develop students' confidence in their ability to work without others' help

- Provide opportunities for students to reflect on what they are learning and how well they are learning it.

Other Educational Resources

One of the characteristics of the general science curriculum that will help all students become scientifically literate is that it should utilize a wide variety of print and non-print resources that have been developed in an interesting and interactive style. Traditional print materials, laboratory equipment, and other materials, audio/visual resources, computer software, CD-ROMs, and videodisks should bean integral part of a student's learning experience wherever possible.

Science Equipment and Supplies

The use of hands-on activities is an essential learning strategy in all science programmes. Hands-on activities can range from simple demonstrations to complex scientific investigations or experiments. At any level of activity, in any learning environment, there exists a need for specific items of equipment or supplies. Such equipment should be appropriate to the grade level. Many items can be home made or improvised using everyday items.

Print Resources

There could be a number of categories of print materials available to science teachers and students—teacher reference materials dealing with science teaching, student textbooks and accompanying teacher resources, science activity books containing ideas for experiments an/or demonstrations, science trade books and reference books (e.g., science encyclopedias), and supplementary science books that augment or complement science textbooks.

Non-Print Resources

There is an increasing variety of resources in other formats such as video, computer software, CD-ROM, and videodisk. Compute software and CD-ROM disks offer simulations and models of real-life situations that permit the investigation of phenomena that are not available because of cost, safety, or accessibility.

The Use of Technology

The use of computers can extend and enrich students' learning in science in important and unique ways. Whenever possible, therefore, students should be encouraged to use computers for a variety of purposes throughout the general science programme. Computers and related technology offer students a very important resource for learning the concepts and processes of science through simulations, graphics, sound, data manipulation, and model building.

The following guidelines are proposed for the implementation of computers and related technology in the teaching and learning of general science:

- Tutorial software to engage students in meaningful interactive dialogue and creatively employ graphs, sound and simulations to promote acquisition of facts and skills, promote concept learning, and enhance understanding.
- Simulation software to provide opportunities to explore concepts and models that are not readily accessible in the laboratory, e.g., those that require:
    - Expensive or unavailable materials or equipment;
    - Hazardous materials or procedures;
    - Levels of skills not yet achieved by the students; and
    - More time than is possible or appropriate in real-time Classroom.

Field Trips and Guest Speakers

The investigative activities include a variety of activities for example, a quick trip to the schoolyard, or nearby field/park. All such activities are marked by active student involvement in attempting to answer the questions about the natural and the constructed world. In order that students know that real nature of science, there is a need to acquaint, expose and fascinate them to the technological and scientific advancement. For achieving this, visits may be organized to science laboratories, factories, universities and other related institutions and organization. The guest speakers from such departments may be invited to schools in the general science educational endeavor that can make students interested in general science.

Instructional Skills and Teachers Training

Instructional skills are the most specific category of teaching behaviours. These are used constantly as part of the total process of instruction. They are necessary for procedural purposes and for structuring appropriate learning experiences for students. No matter how experienced or how effective a teacher may be, the development and refinement of instructional skills and processes is a continual challenge. Instructional skills include such activities as explaining, demonstrating, and questioning.

In order to effectively implement computers and other technology in general science education, teachers should know how to use effectively and efficiently the hardware, software, and techniques described above.

It is recommended that the Government and private institutions should plan and conduct pre-service and in-service teachers' training programmes so that they can develop and refine their instructional and assessment skills.

7 Assessment and Evaluation

Assessment and evaluation of students in general science classes give the teacher an opportunity to identify student understanding and to use that knowledge to guide future planning. This process is described as formative as the information gained provides feedback to modify future teaching and learning.

Another purpose for assessment is to indicate to students and their parents the kind of progress the student is making. Positive regular feedback to students assists in motivating and guiding their future learning. This process may be formative or summative.

In summative assessment, the assessment sums up the accomplishment that has been achieved by the student but does not modify student learning.

Recognising student achievement for certification purposes is another purpose of assessment usually carried out in a summative way.

Diagnostic assessment such as self assessment or students recording their personal reflections in journals and diaries encourages students to identify their own understandings whereas achievement assessment indicates to students, teachers and others what the student can currently do.

Assessing the full range of learning outcomes in General Science requires a variety of assessment strategies, as achievement may be demonstrated in different ways. Strategies for assessment need to be built into general science curriculum planning and should be aligned with teaching and learning goals. This assessment / evaluation should measure all the domains of learning and through it the attainment of the objectives can be measured. The weightage of the domains of learning is given below;

Learning Domains for Measurement	Weightage in Evaluation
Conceptual understanding	60 %
Higher order learning skills (Analysis, Evaluation, Synthesis, Application: Communication, Initiating and Planning)	40 %

Learning outcomes at each level in this curriculum document describes what students should know and be able to do. The indicators, as a set, provide the evidence for the achievement of a learning outcome at a particular level. In making decisions about what is to be assessed, it is not necessary for the whole learning task or student activity to be

assessed. Particular skills or attributes may be selected from a larger task for specific assessment purposes.

Classroom Assessment

The basic steps in the classroom assessment process are:

1. Choose a learning goal to assess
2. Choose an assessment technique
3. Apply the technique
4. Analyze the data and share the results with students
5. Respond to the data

Classroom Assessment Strategies

In the classroom variety of assessment strategies should be used to evaluate and focus on concepts the students have been taught. A list of classroom assessment strategies is given below.

What	When	How	Recording
Science knowledge and understanding: • Biological science • Physical science • Earth and space science	• Ongoing during and after General Science lessons • On completion of units • On completion of projects or practical investigations	• Observation • Student work samples • Oral reports • Talking with students • Diagnostic tasks • Student designed tests • Self-assessment • Modelling • Teacher-designed tests	• Anecdotal records • Annotated class lists • Knowledge-related checklists • Science journals • Cumulative checklists • Photographs, video
Application of scientific knowledge: • Explaining • Predicting	• Ongoing during and after Science lessons • On completion of units • During class discussions	• Concept mapping • Open-ended questions • Problem-solving activities • Debates • Teacher-designed tests	• Anecdotal records • Annotated class lists • Checklists specific to applications • Student portfolios containing samples of student work

What	When	How	Recording
Skills, Processes and Procedures: Design • Observation • Posing questions or hypothesising • Identifying and controlling variables • Planning investigations • Classifying **Measurement** • Using equipment correctly • Justifying measurement procedures • Collecting and recording data **Data handling and interpretation** • Drawings • Presenting data in bar charts, tables and line graphs • Analysing data, commenting on trends • Drawing conclusions	• During and after practical sessions (if any) • When planning and carrying out investigations • During and after excursions	• Observation • Practical tests • Fieldwork • Practical investigations • Surveys and interviews • Practical reports • Design tasks • Using spreadsheets	• Annotated class lists specific to processes identified • Anecdotal records • Folio of student practical reports • Photographs, video, audio recordings
Skills, Processes and Procedures: Scientific Communication: • Appropriate language to a range of audiences	• Ongoing during discussions • Following completion of project reports • During individual or group presentations	• Oral presentations • Practical reports • Drawing • Research project reports • Role-plays, performances • Peer-assessment • Creative writing • Using authoring tools for accessing presenting and communicating information	• Video, audio recordings • Anecdotal records • Portfolio of student practical and research reports

The following table outlines the ways for variety of assessment strategies, listed in the 'How' column on the previous page, can be used to gather data on student learning in General Science.

Teacher Observations Watching work in progress shows student attitudes, communication and process skills.	**Tests** Tests can show the extent of students' scientific knowledge and ability to apply it.
Teacher Questioning Questioning can check the depth of student understanding, show attitudes. Open questions can show ability to apply knowledge to new situations.	**Research projects** Students working on projects can show planning, organising and investigative skills. Project products can show analysing, interpreting and communication skills. ICT should be incorporated where appropriate.
Presentations Oral or written presentations allow students to show their ability to communicate scientifically and their understanding and application of scientific knowledge.	**Practical investigations** In practical activities students can demonstrate investigative abilities, prediction and manipulative skills.
Fieldwork Fieldwork allows students to show planning, investigating and data-collection skills and the application of their scientific knowledge.	**Practical tests** Practical tests can provide information on students' process skills and their ability to apply their scientific knowledge.
Self-assessments Students make judgements about their own learning. They identify what they know and their misconceptions. Students are encouraged in critical reflection.	**Creative writing** Creative writing can show students' depth of scientific understanding, application of scientific knowledge and communication skills.
Student portfolios Samples of work selected by students show the development of their understanding and their progress over time. Samples demonstrate the students' ability to communicate in different ways.	**Student profiles** Samples of student work annotated with teacher comments on the outcomes demonstrated can show progress over time. They may also demonstrate student understanding using a range of learning styles.
Problem-solving Problem-solving activities can show students' investigative and analytical skills and ability to apply scientific knowledge to new situations.	**Concept mapping** Identifying and linking key words can show students' understanding of the relationships between selected words and concepts.

Construction of Test Items

Written test items (objectives, constructed response and extended response questions) should adhere to the following criteria:

1. Items should be clearly written.
2. Each test items should be developed on the understanding level of learners.

3. The difficulty level of the test items should balance with the standardized pattern of 20% easy, 60% moderate and 20% difficult test items.

4. Test items should cover what learners have had opportunities to learn.

Too frequently, these test items measure students' gains in recall of factual information. There are other relevant facts for students to acquire. These are higher levels of thinking or cognition that students should also develop.

These test items should also measure students' achievement in:

- Understanding basic science concepts and acquired learning;
- Evaluating contents in terms of criteria or standards;
- Problem-solving skills;
- Analytical and creative thinking;
- Positive attitudes developed toward science and scientific methods of thinking;
- Ability to work together;
- Relevant concepts and generalizations developed; and
- The ability to manipulate and utilize science equipment.

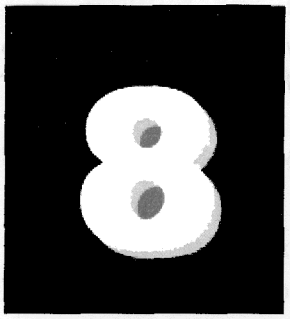
Results from achievement tests may be utilized, along with other data-gathering techniques, to appraise students' progress in the general science curriculum.

Reporting

Reporting on student learning should focus on the extent to which students have achieved the curriculum outcomes. Reporting involves communicating the summary and interpretation of information about student learning to various audiences who require it. Teachers have a special responsibility to explain accurately what progress students have made in their learning and to respond to parents and students inquiries about learning.

Narrative reports on progress and achievement can provide information on student learning that letter or number grades alone cannot. Such reports might, for example, suggest ways in which students can improve their learning and identify ways in which teachers and parents/ guardians/ caregivers can best provide support.

Effective communication with parents/ guardians/ caregivers regarding their children's progress is essential in fostering successful home-school partnerships. The report card is one means of reporting individual student progress. Other means include the use of conferences, notes, and phone calls etc.



Guidelines for Developing Teaching Learning Resources

In most Classrooms student-teacher interaction is limited to reading, writing and speaking. Students remember some of what they hear, much of what they read and more of what they see. However, if students are to remember, understand and embody what they learn, they need to experience their learning. Because each student is unique and learns differently, some students must touch or do in order to experience learning. Using multiple, varied teaching learning resources then is integral so that student's experience as they learn and also develop their multiple intelligences.

In most schools the prescribed government textbook is the only teaching-learning tool. Rarely do teachers use other resources to support the learning. However, many other resources that can be available, accessible and affordable must be used to achieve desired outcomes. These are:

- Textbooks
- Teachers guides
- Students workbooks
- Reference books
- Visual aids such as charts, models etc.
- Videotapes
- Computers (Computer software & Internet websites; online libraries etc.)
- Community (Field trip & Guest speaker)

8.1 Guidelines for the Textbook Authors

A textbook is an important teaching and learning resource and one of the most extensively used resources in our Classrooms. Textbook authors need to consider, among others, following guidelines:

- Introduction to textbook explaining the structure and format of the book, organization of concepts in connection with the curriculum objectives, and how to use the textbook.
- The textbook must have accurate, authentic, and up-to-date material.

- Structure should be written as if talking to a group.
- The material must be sufficient to give students the knowledge they need to understand the concepts, develop the inquiry skills and engage in higher order thinking.
- The material should help students understand the world in which they live, and prepare for life long learning.
- The materials must be error free so it can be trusted.
- The material must be unbiased.
- The book must be attractive and engaging.
- Illustrations must vary from page to page and clearly, accurately, appropriately and neatly drawn.
- Practical and thinking activities suggested must vary from page to page.
- To make writing and studying the textbook easy, colour coding, different levels of headings, etc. can be used.
- End-of-the-chapter exercises should encourage students to think, develop skills, and use information for a variety of purpose.
- Table of contents including topics and subtopics.
- Index.
- Glossary.
- Must be contextually relevant (feasible to use in Classrooms, affordable, examples from context to increase relevance and meaning).

8.2 Guidelines for Writing a Chapter

- Learning outcomes and the required prior knowledge should be stated at the beginning of each chapter.
- Ensure content is up-to date, accurate, authentic and developmentally appropriate.
- Language must be:
    - Consistent;
    - Culturally appropriate;
    - Does not use disparaging, patronizing language or stereotypes about any religion, ethnic group, sex, for people or differing ability or any other community;
    - Gender-neutral;
    - Grammatically correct; and
    - With age appropriate vocabulary.
- Engage and hold readers attention.
- Appropriate hands-on and minds-on activities with assessment indicators are given.
- Recall previous learning, where possible.
- Additional information if required.
- Structure writing to ensure that sentences are simple, and paragraphs deal with single idea etc.
- Relate contents with the technology, society and environment where applicable.

- Write a key points/summary/ concept map at end of chapter reviewing key knowledge and skills.
- Include illustrations where required.
- End-of-chapter exercises:
    - Recall and integrate previous learning
    - Engage students and develop their creativity
    - Move from lower to higher order thinking
    - Develop process skills
    - Develop multiple intelligences
    - Contextually relevant in keeping with local teaching learning
- After 2-3 units a test review for
    - Vocabulary
    - Connect Concepts
    - Understanding
    - Critical thinking
    - Process skills
    - Performance Assessment

8.3 Criteria for Analysis of the Textbook

Following criteria must be considered for selecting learning material for the textbook.

Answers to most of these questions, if in the affirmative, will indicate a good quality textbook.

1. Is the content accurate and up to date?
2. Are important skills developed?
3. Do the illustrations (pictures, drawings, graphs) help to understand the content better?
4. Do the end-of-the chapter exercises encourage students?
    a. To think;
    b. To develop their skills; and
    c. To be creative.
5. Learning Activities
    a. Are activities suitable for the needs of the learner?
    b. Do activities include student participation in real life issues?
    c. Do activities promote scientific inquiry or investigation?
6. Are a variety of assessment strategies suggested?

    (e.g. fill-in-the-blank, multiple choice, project work, exhibitions, open-ended and divergent responses, think tank etc.)
7. Do the text, questions and suggested activities stimulate interest that would lead to further study?
8. Are there biases? a) Religion b) nationality c) gender d) occupation e) Class

9. Is it related to the goals of the curriculum?
10. Is a teacher's guide included?
11. Is it attractive and appealing to children?
12. Is the language readable, understandable, and easy to follow? Appropriate for the children who will use it?
13. Are the following adequate or inadequate?
    - Page size
    - Line spacing
    - Titles and sub-title
    - Font size
14. Are the contents relevant to the needs, age and level of understanding of the students?
15. Is there an introduction and key points/summary?
16. Does it have
    a. An introduction explaining its organization
    b. Table of contents
    c. Glossary
    d. Index

8.4 Guidelines for Writing Teacher's Guide

Teacher guides provide detailed explanation of key concepts. Textbooks usually come with a teacher's guide aimed at informing teachers of how the textbook is written and how best to use it to facilitate student learning. It is a way to teach a particular topic, provide further activities and examples that could be given to facilitate learning. It is the guide easy to follow with textbook and enhances knowledge of or skill in using different instructional strategies.

8.5 Guidelines for Writing Workbook

Workbooks are books that contain writing activities and exercises that are related to each chapter in the textbook. Workbook exercises help to develop students' conceptual understanding of the concepts dealt within the text, to develop skills and to apply knowledge to new situations. Workbook should have:

- Many exercises and activities for each chapter, topic, subtopic
- Exercises and activities must effectively help develop, practice and assess students' content knowledge, skills and higher order thinking
- Accurate exercises (mistake free)
- Different from exercise, activities in text and guide
- Non-repetitive in style, structure, help to engage students
- Clear instructions i.e., easy for students to understand and follow

- Clear illustrations/ examples/ explanations
- Enough space for students' responses (where appropriate)
- Keep teaching-learning environment in view, ensure vocabulary is appropriate for grade level.
- Exercises and activities must be varied, stimulating, challenging and innovative
- Exercises must include constructed and restricted response items
- Avoid using too many activates for one topic or skill. However, where possible, integrate skills and/ or topics into exercises/ activities at different points for deeper development and assessment.

APPENDIX

9.1 Developing Science Skills and Processes

The skills and processes students use and develop in general science curriculum are the same as those used by scientists at work. These are the tools they need to understand the workings of the world. The development of these skills and processes allows students to solve problems, think critically, make decisions, find answers, and satisfy their curiosity. The following skills and processes are central to the presentation of all content and the delivery of instruction and assessment activities in Classrooms:

Science Skills and Processes

Observing	Observing involves obtaining information about objects, situations, or events using as many senses as possible. Observations may be qualitative or quantitative in nature. Observing provides both a basis for new inferences or hypotheses and a tool for testing existing inferences and hypotheses.
Measuring	Observations are quantified using non-standard and then standard units. Length, area, volume, mass, time intervals, and force are among the measurements used. Appropriate measurement instruments and units within the metric system are selected.
Classifying	Classifying involves grouping objects, concepts, or events on the basis of observable properties to show similarities, differences, and inter-relationships.
Inferring	Inferring means suggesting more about a set of conditions than is observed. Inferences are based on observed data and past experience. Inferences may evolve from both direct and indirect evidence and are modified on the basis of new evidence.
Predicting	A forecast is made about future events on the basis of ordered data. Predictions on the basis of ordered data, extrapolation beyond observed patterns of events, and tests of predictions can be made.
Communicating	Communicating is the process of organizing and processing data that occurs between the observation stage and the interpretation or generalization stage. It usually involves organizing "rough" data in a more compact and meaningful way (ordering, rearranging, comparing), depicting the data pictorially or graphically, and processing it mathematically (finding slopes, tangents) to facilitate interpretations.

Hypothesizing	Hypothesizing is an "educated guess" made about an expected relationship between two variables in an attempt to explain a cause-and-effect relationship. Hypotheses are based on observations or inferences about a set of events. A hypothesis should be testable.
Designing Experiments	Experimenting is a cause-and-effect test between two variables. All processes may be involved. This can begin with setting a problem to be solved, identifying the variables to be controlled, making operational definitions, devising the test to be carried out, and following the prescribed procedure.
Controlling Variables	Controlling variables involves the process of deciding which variables or factors will influence the outcome of an experiment, situation, or event, and deliberately controlling all recognized variables in a systematic manner.
Interpreting Data	Interpreting is the process by which sense is made of the observations in the form of inferences, generalizations, or explanations. It is usually a direct response to the problem under investigation and therefore includes judgments about the interpretation to fit with proposed hypotheses, and the limitation of the new knowledge.
Formulating Models	This process involves the use of physical or mental models to describe the behaviour of something that is unfamiliar. Constant vigilance is necessary to ascertain the validity (fit) of the model or analogy to the phenomenon modeled. Models often need revision to accommodate new facts.

9.2 Using Science Process Skills

When Scientists try to find an answer to a question or do an experiment, they use thinking tools called **process skills.** We use many of the process skills when we speak, listen, read, write, or think.

Process Skills

Observe—use the senses to learn about objects and events.

Compare—identify characteristics about things or events to find out how they are alike and different.

Measure—compare an attribute of an object, such as its mass, length, or volume, to a standard unit, such as a gram, centimeter, or liter.

Classify—group or organize objects or events in categories based on specific characteristics.

Gather - gather data by making observations and use them to make inferences or predictions

Record - record data by writing down observations

Display - Data display data by making tables, charts, or graphs

Predict—form an idea of an expected outcome, based on observations or experience.

Hypothesize—make a statement about an expected outcome, based on observation, knowledge, and experience.

Plan and Conduct a Simple Investigation—identify and perform the steps necessary to find the answer to a question, using appropriate tools and recording and analyzing the data collected.

Infer—use logical reasoning to explain events and draw conclusion based on observations.

Interpret (It should be written separately)

Identify and Control Variables—identify and control factors that affect the outcome of an experiment.

Experiment—design ways to collect data to test hypotheses under controlled conditions.

GLOSSARY

This glossary is intended to ensure that terms commonly used in the context of learning out comes are appropriately interpreted

Words and terms defined in the glossary are found throughout the document. The curriculum review committee provided definitions for users to ensure that the meaning of each term was consistent in Grades IV-VIII – high school. These definitions are not vocabulary words to be taught to students in isolation; they represent the terminology students will learn through the lessons prepared by the Classroom teacher.

Carry out	Carry out requires the candidates to put into practice or effect
Classify	Classify requires the candidates to arrange or organize according to the Grade or category.
Compare	Compare requires the candidates to provide both similarities and differences between things or concepts.
Define	Define requires the candidates to give a formal statement or equivalent paraphrase being required.
Demonstrate	Demonstrate requires the candidates to show clearly their learning.
Describe	Describe requires the candidates to state in words (using diagrams where appropriate) the main points of the topic.
Determine	Determine requires the candidates to make a firm decision to do something, often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula (e.g. Young Modulus, relative molecular mass).
Differentiate	Differentiate requires the candidates to perceive or show the difference in or between discrimination.
Discuss	Discuss requires the candidates to involve close examination of a subject with interchange of opinions, to give a critical account of the points involved in the topic.
Distinguish	Distinguish requires the candidates to make noticeable or difference such a pass.
Draw	Draw enables the candidates to formulate or devise from evidence and data at hand.

Explain	Explain requires the candidates to give reasoning or some reference to theory, depending on the context.
Find out	Find out is general terms that may variously be interpreted to calculate, measure, determine, etc.
Illustrate	Illustrate requires the candidates to draw.
Inquire	Inquire requires the candidates to seek for information by asking question; investigating a question or questioning.
Interpret	Interpret requires the candidates to conceive significance of what to present or conceptualize the meaning of, by mean of art.
List	List requires the candidates to give a sequence of points, generally each of one word, with no elaboration. Where a given number of points are specified, this should not be exceeded.
Measure	Measure requires the candidates to obtain quantity concerned from a suitable measuring instrument, e.g. length, using a rule,
Predict	Predict requires the candidates to state a likely future event, process, or situation based on the given information
Recognize	Recognize requires the candidates to know or identify from past experience or knowledge
Relate	Relate requires to bring or link of logical or rational association.
Show	Show requires the candidate to demonstrate a procedure, concept.
State	State requires the candidates to give a concise answer with little or no supporting argument
Suggest	Suggest demands a. to provide ideas to problem or a situation; b. to apply knowledge to novel situation
Use	Use requires the candidates to apply the concept, idea, knowledge.
Write	Write requires the candidates to put words, figures or signs on something on paper with a pen or pencil

General Science Curriculum Development Committee

Dr. Firdous Zahra Bashir	Consultant MP-II (Science), Curriculum Wing, Islamabad
Ms Farah Huma	Head, Habib Public School Development Centre, Karachi
Mrs. Shahnaz Rashid	Assistant Professor, IMCG F-10/2 Islamabad
Ms Samina Ibrahim	Frobels' International School, F-7/2, Islamabad
Ms Tahira Rauf	Assistant Professor, Islamabad College for Girls, F-6/2 Islamabad
Ms. Samia Dogar	Assistant Professor (Physics), Federal College of Education H-9 Islamabad

General Science Curriculum Development Advisory committee

Dr. Firdous Zahra Bashir	Consultant MP-II (Science), Curriculum Wing, Islamabad
Dr. Masoom Yasinzai	Director / Dean Biochemistry, University of Balochistan Quetta
Mr. Iftikhar Ahmad	Assistant Professor, University of Balochistan, Quetta
Dr. Anila Jaleel	Professor (Biochemistry), Zia-ud-Din Medical University Karachi
Dr. Kausar Jamal Cheema	Dean of Natural Science (Biology), Lahore College for Women University, Lahore
Ms Mussaart Shahnaz	Principal, Federal Government Degree College for Women Multan

General Science Curriculum Reviewers committee

Mr. Tariq Mehmood	Subject Specialist, N.W.F.P. Textbook Board, Peshawar
Dr. Mudassar Ahmad khan	Associate Professor, Khyber Medical College, Peshawar
Dr. Masood Khan	Associate Professor, Government College, Swabi
Ms Surriya Yousafi	Head Mistress, Mumtaz Govt. Secondary school, Firdaus Colony, Karachi
Dr. Irfan Ahmed	Assistant Professor, Zia-Ud-Din Medical University Karachi
Mr. Imtiaz Ali	Subject Specialist, Regional Institute of Teacher education (RITE), Haripur
Dr. Shugafta Iqbal	Principal, Government Girls Degree College, Quetta

Syed Saleh Mohammad Shah	Deputy Director Science, Bureau of Curriculum and Extension Wing, Jamshooro, Sindh
Ms Mehanaz Fatima	Lecturer, Government S.M.B. Fatima Girls College, Karachi
Dr. Inayat UR Rehman	Principal, F.G. Piffer High School, Abbottabad
Mr. Azhar Iqbal Malik	T.G.T (Sc), F.G. Piffer High School, Abbottabad
Mrs. Saima Ather	Senior Teacher, Army Public School, Tufail Road, Lahore
Mrs. Rana Arif	S.T.G.T, Army Public School for Girls, Lahore
Ms Safia Khatoon	Subject Specialist, College of Education for Teacher Training, Jamrood
Mr. Iqtadar-ud-din	Associate Professor, Islamabad College for Boys, G-6/3 Islamabad
Mr. Afsar Ali Shah	Trained Graduate Teacher, F.G.Boys Model School, I-10/2 Islamabad
Mr. Ghulam Sarwar	Principal, F.G.Boys Secondary School, I-9/4, Islamabad
Ms Romana Noreen	Trained Graduate Teacher, F.G.Girls H/S Model School, I-9/1 Islamabad
Mr. Amjadullah Khan	Assistant Professor, Islamabad College for Boys, I-10/1 Islamabad
Mr. Haji Muhammad Ayub	Trained Graduate Teacher, F.G.Boys Model School, G-7/4 Islamabad
Mr. Tanveer-Ul-Hassan	Trained Graduate Teacher, F.G.Boys Comprehensive Model School, G-7/2 Islamabad
Ms Saima Khusro	Post Graduate Trained Teacher, F.G.Girls Model School, G-10/1 Islamabad
Ms Shazia Shamim	Senior Teacher, F.G.Girls Model School, G-9/3, Islamabad
Ms Saadia Amjad	Trained Graduate Teacher, F.G.Girls Model School, G-9/3 Islamabad
Ms Noreen Razzaq	Lecturer (Biology), PAF College for Women, Chaklala Rawalpindi
Ms Naheed Anjum	Trained Graduate Teacher, F.G.Girls Higher Secondary School G-9/2, Islamabad

Mr. Waseem Ahmed	Lecturer, Islamabad Model College for Boys, I-8/3, Islamabad
Mr. Muhammad Ashtar	Lecturer, Islamabad Model College for Boys, G-6/3, Islamabad
Ms Tahira Afzal	Assistant Professor, IMCG F-10/2, Islamabad
Ms Ishrat Tanveer	Lecturer, Islamabad Model College for Boys, F-8/1, Islamabad
Mr. Aslam Raza	Vice Principal, F.G Boys Model School, G-9/4 Islamabad
Ms Naheed Anjum	Trained Graduate Teacher, F.G Girls Model School, G-9/3 Islamabad

General Science Curriculum Select Committee

Prof. M. A. Shahid	Director Technical (Retired), Punjab Textbook Board, Lahore
Prof. Dr. Abid Zia	Prof. Dr. Abid Zia, Professor of Chemistry, Vice Principal, Govt. College of Science, Wahdat Road Lahore
Mr. Nadeem Asghar	Lecturer in Biology, Education Department Government of Punjab / Ph.D Scholar F.C. College University, Lahore

REFERENCES

1. Education Policies and Curriculum, National Council of Educational Research and Training, India.
2. National Academy of Sciences. (1995). National Science Education Standards.
3. The New Zealand Curriculum Framework. Ministry of Education, New Zealand Wellington.
4. Ontario, Ministry of Education. The Common Curriculum: Policies and Outcomes 1995.
5. The Review of the National Curriculum in England: the Consultation Materials, 1999. London.
6. Quality assurance in Education: Successful Approaches for Improving Quality in Schools, Colleges and Universities.
7. Lower Secondary Curriculum, Ministry of Education. Singapore.
8. UNESCO. Report to UNESCO of the International Commission on Education for the Twenty-First Century –Learning: the Treasure Within. Paris: UNESCO, 1996.
9. Asia-pacific Regional Workshop on Bridging the gap between Scientists and Science Educators, 2004 (UNESCO) in Shanghai, China.
10. "Curriculum Framework" Curriculum Council of Western Australia.
11. Curriculum Development Centre, Ministry of Education, Malaysia.
12. Critical Thinking Design Model, Harvard Education.
13. Active Learning Practices for Schools. http://learnweb.harvard.edu/alps/.
14. United Nations Educational, Scientific and Cultural Organization (UNESCO). [Online]. http://wwww.unesco.org/.
15. Outcomes-based education: Policy context, Assessment issues and Practice. Curriculum reform: Recent trends and issues. Schooling for the twenty-first century, Paris, OECD.
16. Quality Assurance for Higher Education (http://www.qaa.ac.uk.htm)
17. The Learner-Centered Curriculum, Cambridge University Press.
18. Major Categories in the Taxonomy of Educational Objectives – Blooms' 1956.
19. The Revised Bloom's Taxonomy (1990) by Lorin Anderson.
20. California Department of Education. (1990). Science Framework for California Public Schools (K-12). Sacramento, CA.
21. Michigan Department of Education. (1991). Michigan Essential Goals and Objectives for Science Education (K-12). Lansing, MI.
22. NAEP Science Consensus Project. Science Framework for the National Assessment of Educational Progress.
23. Queensland School Curriculum Council (QSCC) 2002, guidelines on assessment and reporting.
24. Entertaining science: A forum for the promotion of science and scientific literacy in popular culture. http://www.scientificliteracy.org/.
25. Theory of educational assessment: Manitoba Education.