Science standards

Grade 9

Summary of students' performance by the end of Grade 9

Scientific enquiry

Students carry out systematic investigations, process data and evaluate evidence before drawing generalised conclusions. They find, and make critical use of, secondary information sources. They apply scientific knowledge and procedures to real situations. They are familiar with the processes of handling large datasets and using statistical sampling, and understand the importance of working collaboratively. They estimate margins of error and know how to deal with them. They understand that while science can bring great advantages to humanity, it can also damage the environment. They know how scientists work, and understand that the context in which they work affects what they do. They know that science can raise ethical issues and that there are many questions that cannot be answered by science. They know that scientists develop conceptual models to explain evidence collected, and understand the importance of evaluating conflicting models. They communicate their results using a variety of techniques. Students routinely use mathematical relationships to calculate unknown quantities, and they extrapolate straight-line graphs. They represent simple chemical reactions with symbol equations. They use a datalogger when necessary to collect a lot of data, connect voltmeters and ammeters correctly in circuits and read them accurately, and use various other meters correctly. They grow and handle micro-organisms safely.

Life science

Students distinguish between sexual and asexual reproduction, know that sexual reproduction is a major source of genetic variation and know the nature of a clone. They know how sex is inherited. They distinguish between genes and alleles and understand monohybrid inheritance. They know that a gene is a section of DNA and can explain the basic principle of genetic engineering and some of its social and economic dimensions. They know what mutation is and that random mutations cause variation. They know of organisms adapted to live in various conditions and that evolution by natural selection is an explanation for the diversity of living organisms. They know that some disorders are inherited. They explain how substances get into and out of cells. They know how mitosis and meiosis differ. Students explain and give equations for aerobic and anaerobic respiration and fermentation, and know how conditions affect respiration. They describe how skeletal joints and muscles enable locomotion. They know how insulin operates and contrast hormone and nervous control systems. They understand the importance of homeostatic mechanisms and can explain temperature and water regulation. They know the structures and function of nerve cells and about nerve impulses. They know the importance of the reflex arc and the structure and function of the ear and the eye. Students can explain and give the formula for photosynthesis. They give examples of organisms that cause disease. They know about the body's defence systems. They know the function of antibiotics and vaccination. They know that fermentation by micro-organisms produces alcohol.

Materials

Students know that atoms combine in different ways, use symbol equations to show these processes and know that mass is conserved during a chemical reaction. They explain the structure of atoms in terms of protons, neutrons and electrons and describe the structure of any of the first 20 elements. They know how atoms combine by transferring and sharing electrons, and can explain properties of compounds in terms of their bonding. They know what isotopes are. They know that carbon forms covalent compounds with four bonds and that life is based on structures of carbon atoms. They know that polymers are compounds based on long chains of carbon atoms and that their properties and uses are related to their structure. They know that changes in molecular structure account for the changes in properties of clay when it is fired and cement when it sets. Students list the most significant sources of air pollution and explain 'global warming' – what causes it and why it is a reason for concern. They describe the processes that put carbon dioxide into the atmosphere and those that remove it. They describe the processes that lead to acid rainfall and list the consequences of it. They list the main sources of water pollution and some of the processes that use up dissolved oxygen in water; they describe what happens to water that has become depleted in oxygen. Students know the difference between endothermic and exothermic reactions and are familiar with the energy profile of a reaction. They compare the heat energy available from different fuels. They distinguish between renewable and non-renewable energy forms, classify any energy source into one of these categories and explain the origins of fossil fuels. They explain the importance of fossil fuels to the economy of Qatar. They recognise that the Sun is the origin of the energy in all renewable energy sources and was originally the source of energy in fossil fuels.

Earth and space

Students know that stars are grouped in galaxies and that our Sun is a star in the Milky Way galaxy. They know how stars are born and how their ultimate fate depends on their mass. They describe supernovae, neutron stars, pulsars, black holes and white dwarfs and know how they form. They know that the elements that make up the planets of the Solar System originated in a star and understand the process of planetary formation. They have a concept of the magnitude of the Universe in terms of numbers of stars in a galaxy, sizes and numbers of galaxies and the distance between them, and they know the size of a light year. They explain, in outline, our current understanding of the evolution of the Universe and understand how we can use powerful telescopes to look back in time at the early Universe.

Physical processes

Students calculate the pressure exerted by a force. They know that pressure in a fluid depends on its depth and density, and that the pressure at any point in it is the same in all directions. They know that gases and liquids can be put under external pressure and describe some applications of this. They know how a lever can make work easier, and describe applications of this. They calculate the moment of a force and know that the algebraic sum of all moments acting on an object in equilibrium is zero. They distinguish between compressive and tensile strengths of materials and relate this to how materials are used in structures such as bridges. They measure the potential difference between two points in a circuit and know that the sum of the potential differences between the ends of each component in a series circuit is equal to the total potential drop around the

whole circuit. They recognise that the potential difference across a component is a measure of the energy carried by the current and transferred by the component, and know that the electrical energy comes from the cell or power generator. They know how energy is generated commercially from fuels and from hydroelectric generators. They use the relationship between the voltage across a conductor and the current flowing through it, and know that all conductors have resistance, measured in ohms, that impedes the flow of electricity through them. They know how the resistance of a wire depends on its diameter, length and the material it from which it is made. They distinguish AC from DC, are familiar with household ring main circuits, are aware of the dangers of mains electricity and are familiar with safety devices such as fuses, circuit breakers and the earth wire. They calculate the cost of running household appliances. Students distinguish between longitudinal and transverse waveforms and apply the relationship between velocity, frequency and wavelength to water waves, sound and light. They explain reflection and refraction of light in terms of waves They know that the electromagnetic spectrum can be considered as a spectrum of different forms of the same radiation and that each part of the spectrum, of which visible light is one, has different properties and applications. They understand the concepts of pitch and amplitude applied to sound and study sound waves using an oscilloscope and microphone. They explain, in terms of particles, how sound travels through a medium. They roughly measure the velocity of sound in air and know that it is higher in liquids and solids. They know how the ear detects sounds.

The balance between scientific enquiry and the subject content strands

The science standards for Grade 9 are grouped into five strands: four content strands – life science, materials, Earth and space, and physical processes – and the scientific enquiry skills strand, which addresses the development of scientific practical and intellectual skills across all the content strands. The teaching of the enquiry skills strand should be an integral part of the teaching of the content strands.

Assessment weightings for Grade 9

There are three general assessment objectives for the science curriculum:

- knowledge and understanding;
- application of knowledge and understanding, analysis and evaluation of information;
- scientific enquiry skills and procedures.

The balance between these three general objectives will vary from grade to grade. As students' scientific proficiency and experience develops, there should be a greater emphasis on the application of knowledge to solve problems in new situations.

For Grade 9, the weightings of the subject content strands are as follows:

	Life science	Materials	Earth and space	Physical processes
Assessment weighting	30 to 40%	25 to 35%	5 to 15%	30 to 40%

For Grade 9, the weightings of the assessment objectives to be applied to each content strand are as follows:

	Knowledge and understanding	Application, analysis and evaluation	Scientific enquiry skills and procedures
Assessment weighting	45 to 55%	25 to 35%	20 to 25%

Science standards

Grade 9

Scientific enquiry

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Key standards

Key standards are shown in shaded rectangles, e.g. 1.3.

Examples of learning exercises

The examples of active learning exercises shown in italics are intended to be illustrative and do not represent the full range of possible exercises.

Cross-references to scientific enquiry skills

Some of the suggested learning exercises are cross-referenced where appropriate to scientific enquiry skills.

Students should:

1 Use methods of scientific investigation

1.1 Plan investigations, controlling variables and collecting an appropriate range of evidence, using appropriate techniques to ensure accuracy, carry out calculations, identify patterns in observations and data, draw generalised conclusions and test predictions.

1.2 Evaluate the strength of evidence and assess the validity of conclusions before arriving at a viewpoint.

1.3 Search for, select and use critically, secondary information sources, such as sources in libraries and on the Internet.

1.4 Apply scientific knowledge and investigative procedures to real situations.

1.5 Understand the importance of working collaboratively when collecting large quantities of data, and plan, assign responsibilities, organise and set work targets.

1.6 Estimate margins of error and know how these affect their results.

2 Know how scientists work

2.1 Know that science can bring great advantages to humanity but can, if misused, cause irreversible damage to the environment.

2.2 Know how scientists carry out work such as monitoring the environment and controlling industrial processes.

2.3 Know that science can raise ethical and moral issues, and discuss them.

2.4 Know that there are many kinds of question that cannot be answered by science.

2.5 Know that scientists work by developing conceptual models to explain the evidence they collect and that an important scientific process is the evaluation of conflicting models.

2.6 Trace the historical development of some key scientific models and understand the roles of specific scientists in their development.

2.7 Know that scientific work may be affected by the context in which it is undertaken.

3 Process and communicate information

3.1 Present qualitative and quantitative data using a range of methods, such as descriptions and tables and through pictures graphs and diagrams, using ICT methods where appropriate, and draw conclusions from them.

3.2 Use mathematical relationships routinely to calculate physical quantities.

3.3 Perform calculations based on data from straight-line graphs, distinguish between dependent and independent variables, and understand and use extrapolation in drawing conclusions from graphical data.

3.4 Process data in large datasets and report outcomes.

3.5 Use symbol equations to represent simple chemical reactions and physical relationships.

4 Handle equipment and make measurements

4.1 Use a datalogger to investigate phenomena that require the collection of large quantities of data.

4.2 Connect voltmeters and ammeters correctly in an electrical circuit and read them accurately; read a domestic electricity meter.

4.3 Use an oscilloscope to study varying voltages.

4.4 Grow and handle micro-organisms with safety.

4.5 Use an oxygen meter, a respirometer, a barometer and a manometer safely and accurately.

Life science

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Students should:

5 Know the processes leading to genetic uniformity, variation and evolution

5.1 Distinguish between sexual and asexual reproduction; know that sexual reproduction is a major source of genetic variation in animals and plants, while a clone produced by asexual reproduction has the same genetic materials as its parent and will be identical.

Make a collection of plants (or drawings or photographs of plants) to illustrate various forms of asexual reproduction. **Enquiry skills 1.4, 2.5**

Examine the flowers of various plants and identify the sexual organs.

Use coloured beads to show that the genetic material of an organism with two parents is different from that of an organism with just one parent, and that within a population, different breeding partners will produce offspring with genetic variation.

Grow plants from cuttings as an example of asexual reproduction.

5.2 Know what is meant by mutation and that random mutations cause variation among members of the same group of organisms.

Write a set of instruction to do a task. Change one of the instructions and try and do the task. **Enquiry skill 2.5**

Make a model of the base sequences of DNA and relate these to codes for amino acids. Change one of the base sequences and try to relate these to amino acids.

5.3 Give examples of organisms that are adapted to live in various conditions, some of which change over time.

Compare and contrast observed characteristics of fish that live at different depths in the sea. **Enquiry skill 1.4, 3.1**

Using fieldwork, specimens, photographs, charts and drawings, examine plants that live in tidal zones, on shorelines and in the desert. Identify and describe structures that enable their growth in these conditions.

Make monthly observations of different types of plants (including bushes and trees) growing in the desert. **Enquiry skill 2.2**

5.4 Explain the basic principle of genetic engineering and discuss some of the social and economic implications.

Use the Internet to research Dolly the sheep. **Enquiry skills 1.3, 2.3**

Debate the pros and cons of genetic engineering.

Make a display or a series of models to illustrate the steps involved in gene cloning.

ICT opportunity
Use the Internet as a resource.

5.5 Know that evolution by natural selection is an explanation for the diversity of living organisms.

Role play a scientific debate on the evidence for and against evolution. **Enquiry skill 2.3, 2.5, 2.6**

Use the Internet to find out about scientists who have made a contribution to the study of evolution.

ICT opportunity
Use the Internet as a resource.

6 Explain how characteristics are inherited

6.1 Explain how sex is inherited in humans.

Make sets of model chromosomes for male and female parents and use these to investigate the segregation of sex chromosomes into gametes and the formation of male and female offspring. **Enquiry skills 2.3, 2.5**

6.2 Distinguish between genes and alleles and explain the mechanism of monohybrid inheritance where there are dominant and recessive alleles.

Use coloured beads to represent dominant and recessive alleles in parental genes and to illustrate how these alleles pass to gametes and on to progeny. **Enquiry skills 2.3, 2.5, 2.6**

Find out about the work of Mendel.

6.3 Know that a gene is a section of DNA.

Make a simple model of DNA (e.g. using coloured card). **Enquiry skill 2.5, 2.6**

Research the work on the development of the model of DNA.

6.4 Explain how colour blindness, haemophilia, cystic fibrosis and Huntington's chorea are inherited.

Collect information on the frequency of common inherited disorders in Qatar. **Enquiry skills 1.3, 2.3, 2.4**

Given the genetic make-up of parents carrying a deleterious allele, calculate the probability of this showing in the progeny.

7 Explain cell division and how substances cross cell membranes

7.1 Explain how cells divide by mitosis during growth and by meiosis to produce gametes.

Examine microscope slides, photomicrographs or diagrams and use these to make a presentation on the movement of chromosomes in mitosis and in meiosis. **Enquiry skill 3.1**

7.2 Explain diffusion and osmosis as mechanisms for the movement of substances into and out of cells.

Use ink in water and smoke or perfume in a room to demonstrate diffusion. **Enquiry skill 1.2**

Make model cells from visking tubing. Fill with different concentrations of sugar solution. Place the cells in water and sugar solutions. Leave for some time and observe if water has passed into or out of the cells.

Hollow out a well in a peeled potato and place some salt in the well. Put the potato in a dish with a little water. Leave for some time and observe the movement of water into the well to dissolve the salt.

8 Explain aerobic respiration

8.1 Give the word and formula equations for aerobic respiration; explain the process as a cellular biochemical reaction in animals and plants in which food acts as a respiratory substrate and reacts with oxygen to release energy and produce carbon dioxide and water.

Use a respirometer to investigate gas exchange in respiration. **Enquiry skills1.3, 3.5, 4.1, 4.5**

Place germinating beans in one vacuum flask and boiled beans in another. Leave for some days and compare the temperatures of the flasks. Test for both oxygen and carbon dioxide.

Investigate the energy content of foodstuffs by experiment and from their labels.

8.2 Know how the rate of respiration is affected by temperature, oxygen concentration and the availability of a respiratory substrate.

Use a respirometer to measure insects' respiration rates at different temperatures. **Enquiry skill 1.1, 1.2, 4.5**

9 Describe how skeletal joints and muscles enable locomotion

9.1 Describe the structure of a joint and the types of joints in the human skeleton.

Examine a skeleton, models, charts or pictures to locate and classify different types of joint. **Enquiry skill 1.2, 3.1**

Make model joints.

9.2 Describe how the contraction and relaxation of muscles enables locomotion.

Use specimens, models, charts or photographs to study the position of muscles in relation to joints. **Enquiry skill 1.2, 3.1**

Make a model arm using pieces of wood or strong card for bones and rubber bands as muscles.

10 Explain hormone and nervous homeostatic control systems

10.1 Explain the importance of maintaining a constant internal environment.

10.2 Explain the ways in which hormonal control occurs and the effects of insulin.

Determine the number of students who know someone with diabetes. Collect case studies of how people control diabetes with insulin. **Enquiry skill 1.3, 1.5**

Research the commercial production of human insulin.

10.3 Know the general structure and functions of the human nervous system, the structure and function of types of nerve cells, and the pathways taken by a nerve impulse in response to a stimulus.

Use a microscope to examine nerve cells. **Enquiry skill 2.5**

Act out a nerve impulse transmission.

Make a poster to illustrate the main parts of the nervous system. **Enquiry skill 3.1**

10.4 Know the functioning and importance of the reflex arc.

Test students' reflexes by getting them to try to catch a ruler dropped between their fingers. **Enquiry skill 2.5**

Examine the size of the pupil of the eye in bright and dark conditions.

10.5 Know the structure and function of the human eye and ear.

Examine models of the eye and ear. **Enquiry skill 1.4, 3.1**

Use empty and water-filled round-bottom flasks to investigate the image formed on the eye.

Make a pin-hole camera.

Investigate the blind spot and peripheral vision.

Investigate the frequencies of sounds that can be heard.

Compare the sizes and positions of ears of different animals.

10.6 Know how the body controls temperature and water balance.

Examine data on the body's water intake and output in cool and hot conditions. **Enquiry skill 2.5, 3.1**

Record variations in body temperature over the course of a day and when in different environmental temperature conditions.

10.7 Know the similarities and differences between hormone and nervous control systems.

Discuss case studies of reactions in response to different stimuli and discuss evidence for these being nervous or hormonal. **Enquiry skill 2.5, 3.1**

11 Explain the biochemistry of photosynthesis

11.1 State the word and formula equations for photosynthesis; explain the process as a biochemical reaction in chloroplasts that involves the absorption of light energy, which causes water and carbon dioxide to react to generate glucose and oxygen.

Place a water plant in a weak solution of sodium bicarbonate. Place in bright light. Observe bubbles of gas being released. Collect the gas and test for oxygen with an oxygen meter. **Enquiry skill 1.1, 1.2, 3.5, 4.5**

Use a microscope to examine the chloroplasts in a green leaf.

Place a plant with de-starched leaves in bright light. Leave for some hours. Test the plant's leaves for starch. Compare with a similar plant kept in darkness.

12 Know how harmful micro-organisms can be controlled and that micro-organisms cause fermentation

12.1 Provide examples of diseases caused by micro-organisms (bacteria, fungi, protozoa and viruses).

Make posters to display types, shapes and sizes of micro-organisms that cause disease. **Enquiry skill 1.3, 3.1**

Do a survey to find out who has had an illness caused by a micro-organism. Draw charts to show the frequencies of different illnesses.

12.2 Know that antibiotics are effective against bacterial illness and explain why vaccination can protect against viral illness.

Place antibiotic discs on bacterial cultures and observe the effect on the growth of the bacteria round the disc. **Enquiry skill 1.1, 1.2, 4.5**

Visit a pharmacy and collect information on the range of antibiotics available and the infections against which they are effective.

12.3 Know that antibodies help protect the body from the effects of microbial infection.

Watch a video on antibody action and write a review. **Enquiry skill 3.1**

Discuss the effects of a malfunctioning antibody system.

12.4 Give the word equations for anaerobic respiration; explain the process as a cellular biochemical reaction in which a respiratory substrate reacts without oxygen to release energy and produce carbon dioxide and alcohol or lactic acid; know that when carried out by micro-organisms, this is termed fermentation.

Use library resources to investigate the use of fermentation to produce useful products. **Enquiry skill 1.3, 4.5**

Materials

By the end of Grade 9, students know that atoms combine in different ways, use symbol equations to show these processes and know that mass is conserved during a chemical reaction. They explain the structure of atoms in terms of protons, neutrons and electrons and describe the structure of any of the first 20 elements. They know how atoms combine by transferring and sharing electrons, and can explain properties of compounds in terms of their bonding. They know what isotopes are. They know that carbon forms covalent compounds with four bonds and that life is based on structures of carbon atoms. They know that polymers are compounds based on long chains of carbon atoms and that their properties and uses are related to their structure. They know that changes in molecular structure account for the changes in properties of clay when it is fired and cement when it sets. Students list the most significant sources of air pollution and explain 'global warming' – what causes it and why it is a reason for concern. They describe the processes that put carbon dioxide into the atmosphere and those that remove it. They describe the processes that lead to acid rainfall and list the consequences of it. They list the main sources of water pollution and some of the processes that use up dissolved oxygen in water; they describe what happens to water that has become depleted in oxygen. Students know the difference between endothermic and exothermic reactions and are familiar with the energy profile of a reaction. They compare the heat energy available from different fuels. They distinguish between renewable and non-renewable energy forms, classify any energy source into one of these categories and explain the origins of fossil fuels. They explain the importance of fossil fuels to the economy of Qatar. They recognise that the Sun is the origin of the energy in all renewable energy sources and was originally the source of energy in fossil fuels.

Students should:

13 Understand the structure of atoms and molecules

13.1 Know that atoms are made up of a nucleus consisting of protons and neutrons surrounded by electrons in specific orbitals or shells.

Study how our understanding of atomic structure has changed over time.

Enquiry skills 2.5, 2.6

ICT opportunity

Find out from the Internet about the work of scientists involved with the development of atomic theories.

13.2 Define and use the terms *proton number*, *mass number* and *isotope*, and represent isotopes symbolically using the numbers.

13.3 Know that electron shells can contain only a fixed number of electrons and that this can explain the structure of the periodic table.

Draw a diagram, or make a display, of the periodic table up to element 20 (calcium) showing the atomic structure of each element.

Enquiry skill 3.1

ICT opportunity

Use graphics software.

13.4 Know the charges and approximate masses of the proton, neutron and electron and use these to calculate the mass and overall charge of any atom or ion.

13.5 Know how a full outer shell leads to the lack of chemical reactivity of the group VIII elements and know that the uses of the group VIII elements derive from their lack of chemical reactivity.

Make a collection of common devices that use inert gases.

13.6 Know how atoms combine using ionic (electrovalent) or covalent bonds.

Make displays or draw diagrams showing how a number of atoms combine using electrovalent and covalent bonds.

Enquiry skill 3.1

13.7 Know that ionic compounds form crystals containing a giant lattice of ions whereas covalent compounds form discrete molecules.

13.8 Know the number of bonds formed by the elements hydrogen, oxygen, carbon and nitrogen in covalent compounds and be able to represent compounds of these elements diagrammatically.

Draw the structures of compounds such as water, ammonia, methane and carbon dioxide.

13.9 Explain the difference in the physical properties of ionic and covalent compounds in terms of their bonding.

Make a display of typical electrovalent and covalent compounds that contrasts their properties.

13.10 Explain how atoms are bonded together in metals and how this can explain why they are good conductors of heat and electricity.

13.11 Know what is meant by the valency of an element and how to use this in determining the formulae of its compounds.

Make a set of 'valency cards' for positive and negative ions, which have a common width but a length that reflects the valency. Use the cards to deduce the formulae of ionic compounds by placing them together.

14 Know that the properties of materials, and the use we make of them, depend on their molecular structure

14.1 Know that materials such as wood, wool and cotton, that are derived from living things, have molecular structures that consist of a skeleton of carbon atoms with atoms of a small number of other elements joined to them.

Draw structures of simple carbon compounds such as methane, ethane and ethanol, and also the polymer polythene.

14.2 Know that a polymer is a compound made up of repeating small units joined together by covalent bonds and that many polymers have a structure that is based on long chains of carbon atoms.

Make a collection of natural and synthetic polymers and classify them according to their physical properties.

14.3 Give examples of natural and synthetic polymers and show an understanding of how the use that we make of a polymer is related to the characteristic features of its molecular structure.

Test polythene by determining the force needed to stretch it in two perpendicular directions and relate this information to the arrangement of the polymer's molecules. **Enquiry skill 1.1**

Devise a test to compare the rigidity of different polymers (e.g. different plastics, wood) and relate rigidity to cross-linking between the polymer chains.

Test cloth made from different fibres (e.g. wool, cotton, nylon, polyester) for the capacity to absorb water and relate this to the ability of certain polymer molecules to attract water. Relate this also to the comfort of clothes made from the cloth.

Test different fibres (e.g. wool, cotton, nylon, polyester) for their ability to stretch when pulled and then return to the original length, and relate this to the ability of the polymer to form a coiled structure by links between one part of the chain and another. **Enquiry skill 1.1**

14.4 Know that oil and natural gas are the raw materials from which synthetic polymers (plastics and synthetic fibres) are commonly made and that many are made in Qatar.

Make a study of what polymers are made in Qatar. **Enquiry skills 2.2, 2.7**

Visit a plastics plant, such as those at Mesaieed.

14.5 Know that an important constituent of wood is a natural polymer called cellulose, which is arranged in long chains with cross-links between the chains, and that this structure gives wood its tensile strength.

Tear a sheet of newspaper (made from wood) in two directions. Notice that it is easier to tear the paper in the direction of the lay of the fibres than across it. **Enquiry skill 1.2**

Compare the tensile strength of wood with that of steel.

14.6 Know that changes in molecular structure account for the changes in the properties of clay when it is fired.

14.7 Know that clay consists of small molecules that can easily move around next to each other when molecules of water are present and that this is why wet clay is soft; know that when clay is fired, links are made between the molecules that make pottery strong, and that this process is irreversible.

Test the compressive strength of unfired and fired clay bricks. **Enquiry skill 1.1**

Devise a test for comparing the hardness of fired and unfired clay.

14.8 Know that the setting of concrete is an irreversible process by which a network of interlocking crystals is formed, and that this is what gives concrete its strength.

Discuss the slow hydration of calcium and aluminium silicate crystals during the setting of concrete and the role of the water, sand and aggregate in the process.

Enquiry skill 1.1

Make some concrete and allow it to set slowly over many days by keeping it moist. Look at its crystalline structure with a magnifying glass before and after setting.

Test concrete bricks made from different mixtures for breaking strength.

Devise tests to compare the strength of concrete that has set quickly and concrete that has set slowly over a week by being kept moist.

14.9 Discuss the ethical and moral questions raised by the way we exploit our understanding of materials to make explosives, nerve agents, biocides, etc.

Enquiry skill 2.3

15 Understand the sources of chemical pollution of the environment and the need to minimise it

15.1 List and explain the most significant sources of air pollution.

List important global sources and important local sources of air pollution.

15.2 Explain the causes of 'global warming'; know why scientists are concerned about it and the steps they propose to counter it.

Make a study of the processes that put carbon dioxide and other greenhouse gases into the atmosphere in Qatar and in the wider world.

Enquiry skills 1.3, 1.4

ICT opportunity

Explore secondary information sources on the Internet.

Test car exhaust gases for carbon dioxide.

Study the ways that carbon dioxide emissions could be reduced.

Use the Internet to obtain data on how global carbon dioxide concentrations have increased in the last 100 years and demonstrate this graphically.

Discuss the merits of various proposals made by scientists to remove carbon dioxide from the atmosphere, including those proposed under the Kyoto protocol.

15.3 Know that air pollution is an inevitable consequence of the petrochemical and petroleum industries and explain steps taken by companies to minimise it.

Enquiry skill 2.7

15.4 Describe the processes that lead to acid rainfall and list the consequences of it.

Bubble air through water containing universal indicator.

Make a study of gas production in Qatar, with particular reference to the way that sulfur impurities in the gas are removed before the gas is used.

Make a study of the consequences of acid rainfall in some other parts of the world (e.g. northern Europe).

Enquiry skills 1.3, 1.4, 2.1, 2.2

ICT opportunity

Explore secondary information sources on the Internet.

Visit an industrial plant that uses Qatar gas and find out how sulfur is removed from the gas.

15.5 List and explain the main sources of pollution of water.

Make a study of how sewage water is treated in Doha to prevent pollution of the sea and the groundwater.

15.6 Know that pollution of the sea by waste heat from industry is a major problem for Qatar industry; know how this form of pollution is being prevented.

Make a study of the cooling of industrial processes in Qatar, including a visit to a cooling plant such as the one at the Ras Laffan.

Enquiry skills 2.1, 2.2, 2.7

15.7 Explain the importance of maintaining the concentration of dissolved oxygen in water and describe some of the processes that reduce it.

Measure/monitor the dissolved oxygen content of a natural water source or an aquarium.

Make a presentation on air or water pollution in Qatar, and the steps taken to combat it.

Enquiry skills 1.3, 2.2, 3.1, 4.1

ICT opportunities

Use a datalogger to monitor dissolved oxygen in water. Create a PowerPoint presentation.

16 Understand the importance of energy resources

16.1 Know that in some reactions energy is given out and in others it is taken in.

Study examples of exothermic and endothermic reactions (e.g. the burning of magnesium and the action of acid on potassium hydrogencarbonate).

16.2 Construct and interpret an energy profile of a reaction.

Draw example profiles showing exothermic and endothermic reactions and showing the effect of a catalyst on a profile.

16.3 List the main sources of energy available to us and classify them as renewable and non-renewable.

Make an exhibition of different fuels and classify them as renewable and non-renewable.

16.4 Name the common fossil fuels and explain their origin.

Make a display to show the formation of fossil fuels and how they are obtained, with particular reference to the Qatar gas field.

16.5 Know what chemical reactions take place when fuels burn.

Compare the heat given out by different fuels.

Enquiry skill 1.2

16.6 Describe the different ways in which we can harness energy from the Sun, either directly or indirectly through wind energy and hydropower.

Design a thermal solar panel and investigate its effectiveness.

Carry out a research project into the latest ways being developed of harnessing solar energy directly or indirectly.

Enquiry skill 1.1, 1.2

ICT opportunity

Use the Internet as a resource.

Carry out research into how satellites and the International Space Station obtain their energy.

16.7 Know that plants and animals require energy to survive and that their source of energy is ultimately the Sun.

Investigate the energy content of foodstuffs by experiment and from their labels.

16.8 Explain how the Sun was the source of energy now stored in fossil fuels.

Earth and space

By the end of Grade 9, students know that stars are grouped in galaxies and that our Sun is a star in the Milky Way galaxy. They know how stars are born and how their ultimate fate depends on their mass. They describe supernovae, neutron stars, pulsars, black holes and white dwarfs and know how they form. They know that the elements that make up the planets of the Solar System originated in a star and understand the process of planetary formation. They have a concept of the magnitude of the Universe in terms of numbers of stars in a galaxy, sizes and numbers of galaxies and the distance between them, and they know the size of a light year. They explain, in outline, our current understanding of the evolution of the Universe and understand how we can use powerful telescopes to look back in time at the early Universe.

Students should:

17 Describe the structure of the visible Universe today and show an understanding of its evolution

17.1 Know that stars are grouped by gravitational attraction in galaxies, and that our Sun is a star in the Milky Way galaxy.

Study stars in the night sky with binoculars, noting different brightnesses and colours.

Download pictures of galaxies from the Internet.

17.2 Develop a concept of the size and number of stars and galaxies, the distances between them, and the size of the Universe; know the size of the light-year.

Identify a number of bright stars in the night sky using star maps. Find out on the Internet how big they are compared with our Sun and how far away they are.

17.3 Show an understanding of how stars are created, that they are made mainly from the element hydrogen, and that their ultimate fate depends on their size and can lead to supernovae, white dwarfs, neutron stars (pulsars) or black holes.

Download photographs of nebulae (clouds of hot glowing gas) where new stars are being created and also nebulae that are the remnants of stars that have exploded as supernovae in the past.

Make an Internet study of the known history of the Crab Nebula, the remnants of a supernova that exploded in the thirteenth century, at the centre of which is now a pulsar.

Make an Internet study of the evidence for the existence of black holes.

17.4 Explain the process of element formation in stars.

17.5 Understand how the process of element formation produces the energy of the star.

17.6 Describe how planets are formed when a star attracts the remains of an older exploded star into a disc around it by gravitational attraction.

17.7 Explain why powerful telescopes allow us to look back in time to a period when the Universe was much younger than it is now.

Download images of the early Universe taken by the Hubble Space Telescope and compare them with the structure of galaxies downloaded in the exercise with Standard 17.1.

17.8 Explain, in outline, the theory that all matter in the Universe was generated in a 'big bang' around 14 billion years ago, that the Universe has been expanding ever since, and that time and space also started with the 'big bang'.

Make a display charting of the evolution of the Universe.

17.9 Show an understanding of how the Universe can be finite but limitless.

ICT opportunity

Important information and pictures covering this whole topic are widely available on the Internet.

Enquiry skills

Enquiry skills 2.4 and 2.5 can be developed throughout this topic.

Physical processes

By the end of Grade 9, students calculate the pressure exerted by a force. They know that pressure in a fluid depends on its depth and density, and that the pressure at any point in it is the same in all directions. They know that gases and liquids can be put under external pressure and describe some applications of this. They know how a lever can make work easier, and describe applications of this. They calculate the moment of a force and know that the algebraic sum of all moments acting on an object in equilibrium is zero. They distinguish between compressive and tensile strengths of materials and relate this to how materials are used in structures such as bridges. They measure the potential difference between two points in a circuit and know that the sum of the potential differences between the ends of each component in a series circuit is equal to the total potential drop around the whole circuit. They recognise that the potential difference across a component is a measure of the energy carried by the current and transferred by the component, and know that the electrical energy comes from the cell or power generator. They know how energy is generated commercially from fuels and from hydroelectric generators. They use the relationship between the voltage across a conductor and the current flowing through it, and know that all conductors have resistance, measured in ohms, that impedes the flow of electricity through them. They know how the resistance of a wire depends on its diameter, length and the material it from which it is made. They distinguish AC from DC, are familiar with household ring main circuits, are aware of the dangers of mains electricity and are familiar with safety devices such as fuses, circuit breakers and the earth wire. They calculate the cost of running household appliances. Students distinguish between longitudinal and transverse waveforms and apply the relationship between velocity, frequency and wavelength to water waves, sound and light. They explain reflection and refraction of light in terms of waves They know that the electromagnetic spectrum can be considered as a spectrum of different forms of the same radiation and that each part of the spectrum, of which visible light is one, has different properties and applications. They understand the concepts of pitch and amplitude applied to sound and study sound waves using an oscilloscope and microphone. They explain, in terms of particles, how sound travels through a medium. They roughly measure the velocity of sound in air and know that it is higher in liquids and solids. They know how the ear detects sounds.

Students should:

18 Understand the concept of pressure and its applications

18.1 Calculate the pressure exerted by a force knowing the area over which it acts.

Measure the force exerted by a brick placed on foam plastic and show that the compression of the foam is related to the pressure exerted by the brick when it is placed face, edge and end downwards on the foam. **Enquiry skill 3.1**

List and display devices that are designed to exert low pressure (e.g. wide car tyres, camel's feet) and high pressure (e.g. pin, knife blade).

18.2 Know that pressure in a fluid depends on the depth and density of the fluid, and that the pressure at any point in it is the same in all directions.

Make a device that shows that pressure varies with water depth.

Use barometers to measure air pressure. **Enquiry skills 3.1, 4.5**

18.3 Know that gases and liquids can be put under external pressure and describe some applications of this.

Study the history of the steam engine and demonstrate a model steam engine.

Create a display of objects that use compressed gas to work.

Make a model of a car braking system.

Demonstrate a hydraulic jack lifting a heavy weight using a small force.

19 Apply knowledge of forces to understand simple machines and structures

19.1 Know how a simple machine such as a lever can make work easier and that it has many applications.

Study a number of simple levers (e.g. wheelbarrow, crowbar) and compare the force required to lift a load with and without the lever. **Enquiry skill 1.4**

Identify devices and situations in which a turning force is used (e.g. in machines such as a bicycle, in games, in gymnastics, in tools).

19.2 Know that the turning effect of a force is called its *moment* and calculate the moment of a given force.

19.3 Know that, in a system of moments in equilibrium, the anticlockwise moment is equal to the clockwise moment and use this in calculating unknown forces.

Investigate balancing using a pivoted metre rule; find the balancing law. **Enquiry skill 1.2**

19.4 Distinguish between compressive and tensile strength of materials and relate this to the way the materials are used in structures such as buildings and bridges.

19.5 Know that structures such as bridges are systems of moments in equilibrium that take best advantage of the specific properties of the materials from which they are made. **See Standards 17.5, 17.6**

Devise experiments for investigating the tensile strength of some common materials (e.g. polythene, cotton yarn, nylon fibre fishing line, lengths of spaghetti) and the compressive strengths of others (e.g. mud or clay bricks when wet, dry and after firing). **Enquiry skill 1.1**

Build model bridges from simple materials such as mud bricks (high compressive strength but low tensile strength), spaghetti (good tensile strength but easily broken) and cotton (flexible and good tensile strength). Use different kinds of bridge construction (e.g. arch, cantilever, girder, suspension) that make the best use of the properties of the materials. Test the bridges to destruction.

20 Understand how energy is transmitted in the form of waves

20.1 Know that energy can be transmitted down a rope or through water in the form of waves.

Show the transmission of waves using everyday items (e.g. a rope, a slinky spring, a pool or water in a ripple tank). **Enquiry skill 1.4**

20.2 Distinguish between longitudinal and transverse waves.

Use a slinky spring to demonstrate longitudinal and transverse waves.

20.3 Understand the relationship between velocity, frequency and wavelength, and perform calculations using the relationship.

Use waves in a ripple tank or a swimming pool to demonstrate the relationship between velocity, frequency and wavelength.

20.4 Explain the reflection of sound and light in terms of waves.

Show reflection and refraction of water waves using a ripple tank and show the similarities with the transmission of light and sound.

20.5 Explain the refraction of light and water waves in terms of the change in velocity of waves.

20.6 Know that the electromagnetic spectrum can be considered as a spectrum of different forms of the same radiation, and that each part of the spectrum, of which visible light is one, has different properties and applications.

Make a diagram or display showing the velocity and frequency range of different parts of the electromagnetic spectrum and the uses we make of each part.

20.7 Know that the velocity of all electromagnetic radiation in a vacuum is the same.

Make a table of calculation results showing how long light takes to get to us from different light sources (e.g. a television set, a distant streetlight, the Moon, the Sun, a nearby star, the Andromeda galaxy – our nearest neighbour galaxy).

20.8 Know how, in terms of the movement of particles, sound is transmitted through a medium and how the ear detects sounds.

20.9 Know that pitch is determined by the frequency of a sound and that amplitude is a measure of the loudness and is measured in decibels, which is a logarithmic scale.

Mathematics

An understanding of logarithms to the base 10 is helpful but not essential.

Investigate the limits of human hearing in terms of pitch and find out the limits in terms of loudness.

Investigate the differences between pure sounds from a tuning fork or a signal generator and mixtures of sounds, such as those produced by musical instruments and the human voice.

20.10 Make an estimate of the velocity of sound in air.

Determine an approximate value for the velocity of sound by the echo method. **Enquiry skill 1.6**

20.11 Know why sound travels faster and more efficiently through solids and liquids than through gases such as the air and list some common applications of this.

Compare the transfer of sound vibrations through solids and liquids with the transfer of sound through air.

Investigate how we detect vibrations from earthquakes as far away as the other side of the world.

21 Understand potential difference and resistance

21.1 Understand the concept of electrical potential between two points on a circuit and know that it is measured in volts using a voltmeter.

21.2 Know that the total potential drop around a circuit is equal to the sum of the potential differences across each series component.

Measure the potential difference between successive points around a circuit. Also measure the current flowing through each component of the circuit. **Enquiry skill 4.2**

21.3 Recognise that the potential difference across a component is a measure of the energy carried by the current and transferred by the component, and that a potential difference only occurs in a circuit when a component offers some resistance to the flow of the current.

Compare the potential difference across different components in a series circuit to show that different components offer different resistances to the flow of current.

21.4 Show the relationship between the voltage across a conductor and the current flowing through it.

Explore Ohm's law for a resistance wire.

Enquiry skills 3.1, 3.3

Plot V against I for a non-Ohmic conductor such as a light bulb.

21.5 Know that electrical components have resistance that impedes the flow of electricity through them and that this is measured in ohms.

21.6 Calculate the resistance of a component knowing the current passing through it and the potential difference between its ends.

21.7 Know how the resistance of a wire depends on its diameter, length and the material rom which it is made.

Devise fair tests to explore the relationship between voltage and current for resistance wires of different length, diameter and material.

21.8 List, and account for, the electrical uses of metals such as gold, copper, nichrome and tungsten.

22 Know how household electricity is made and used, and recognise the dangers associated with it

22.1 Distinguish alternating current (AC) from direct current (DC) and know why household electricity is AC and not DC.

Look at fluorescent light with a CCD light detector and datalogger.

ICT opportunity

Use a datalogger.

22.2 Know that household electrical energy comes from a cell which generates DC or from an electrical power generator which generates AC.

Show the inside of a dry cell and establish that there is a chemical change in it that converts chemical energy to electrical energy.

22.3 Know how AC is produced commercially using a generator that is usually driven by a steam turbine, a gas turbine or a diesel engine, or by moving water from a dam.

Show how an electric motor can be used as a generator.

Show that a bicycle dynamo is a simple generator.

Show how a generator produces AC through slip rings and DC through a commutator.

22.4 Know that electricity in Qatar is generated using gas turbines and that much of the waste heat from the turbines is used to make potable water from seawater.

Carry out research to assess the environmental consequences of different ways of generating electricity.

Enquiry skills 1.3, 2.1

22.5 Know that transducers such as radios and light bulbs convert less electrical energy over a given time than appliances such as heaters and cookers.

22.6 Be familiar with household ring main circuits, with the common dangers of household electricity, and with the purpose and operation of safety devices such as fuses, circuit breakers and the earth wire.

Make a model ring main.

22.7 Know why mains circuits that supply the sockets are make of thicker wires and have higher rated circuit breakers than lighting circuits.

22.8 Know that the unit of household electrical energy is the kilowatt-hour and be able to work out the cost of running different appliances from their power rating.

Establish the power rating of different appliances and work out the cost of running them for 1 hour.

Perform calculations converting kilowatt-hours to joules and vice versa.