

Middle and Upper School Science Standards & Benchmarks

1. SCIENTIFIC INQUIRY

a) Students will demonstrate their understanding of the importance of curiosity, honesty, open-mindedness, and scepticism in their own efforts to understand how and why universal phenomena exist and occur.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Keep scientific records of investigations which reflect the importance of reporting honestly, clearly, and accurately. | Recognize the value of repeating experiments. | | | |
| Recognize that there may be more than one reasonable way to interpret a given set of scientific findings. | Question the value of arguments based on very small samples of scientific data, biased samples, or samples for which there was no control sample. | Suggest alternative ways of explaining scientific data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. | Exhibit traits that show an understanding of how honesty, curiosity, transparency, and scepticism affect the progress of scientific inquiry. | Offer different explanations for the same scientific evidence, and explain why it is not always possible to tell which explanation is best supported. |
| Understand that hypotheses are valuable if they lead to fruitful investigations, even if the hypotheses turn out not to be true. | Draw independent conclusions based on data, using critical reasoning to construct models, rationally defend conclusions, and recognize the validity of other positions | Identify the flaws of arguments based on the faulty, incomplete, or misleading use of numbers, such as instances in which (1) average results are reported, but not the amount of variation around the average, and (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend..."). | Know that scientists do not have models that explain all phenomena, and that current models range from the proven — the Earth is round — to the speculative — cancers are viral. | Critically analyze and evaluate experimental designs for accuracy, including variables, controls, adequate data sampling, and logical conclusions and suggest design improvements when appropriate. |

b) Students will communicate scientific ideas and activities clearly.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Know how to write clear, step-by-step instructions for conducting scientific investigations, operating equipment, or following a procedure. | Write and describe coherent accounts of scientific activities and alternative interpretations of the results. | Understand and produce writing for scientific purposes that incorporates circle charts, bar and line graphs, two-way data tables, diagrams, and symbols. | Make and use tables, charts, graphs, and scale drawings to make scientific arguments and claims in oral and written presentations. | Choose appropriate summary statistics to describe group differences, always indicating the spread of the data as well as the scientific data's central tendencies |
| Analyze and evaluate scientific data to draw a valid conclusion | | | | |
| | | Understand the importance of verbal accuracy and explicit statement of critical assumptions when stating a position. | | Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions. |

c) Students will be familiar with the character of scientific knowledge and inquiry and how it is achieved.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Describe why (such as to explore new phenomena, check previous results, compare theories) and how (by collecting evidence, reasoning, devising hypotheses, and creating explanations) scientists conduct investigations. | Explain why and how (for example, by repeatedly and independently replicating experiments) scientists determine if experimental results are reliable. | Understand that if more than one variable changes at the same time in an experiment, the outcome may not be clearly attributable to any one variable, and that sometimes scientists can design research to account for this. | Use hypotheses to guide choices of what data to pay attention to, what additional data to seek, and how to interpret both new and previously available data. | Explain how and why scientific teams seek out the possible sources of bias in their investigations' hypotheses, observations, data analyses, and interpretations, and follow this model in the student's own work. |
| Understand and follow scientific ethical norms in conducting research with animals and humans who are unable to make fully informed choices (such as very young children). | Explain how scientists try to prevent their experiments from bias in what is observed, missed, and concluded in investigations (for example, through independent studies). | | Understand that progress in scientific understanding often manifests itself in more reliable explanations and more accurate predictions, and is achieved by testing, revising, and sometimes rejecting, old and new theories. | Explain why scientists often control conditions in experiments, and what they do when controlled conditions are not possible. |
| | | | Exhibit understanding that a change in the scientific view of how the world works is occasionally major, but is more often a small modification of prior knowledge, and that these new ideas often encounter vigorous criticism. | |
| | | | Describe how and why new ideas in science can be limited and influenced, including cultural and historical context, and how history in turn has been shaped by science | Explain how choices for scientific research can be influenced by funding, which can come from sources such as federal government agencies, NGOs, industry, and private foundations. |
| | | | Explain how and why ethical considerations can limit scientific research. | Explain why science uses practices such as peer review and publication. |

d) Students will be able to select and use tools and instruments to conduct scientific activities.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Know how to use sophisticated tools and instruments when measuring length, volume, weight, elapsed time, rates, and temperature. | | | Understand the applications and basic functioning of complex pieces of scientific equipment (for example, PCR, cathode ray tube) and be capable of basic troubleshooting | Select the most appropriate tool for a specific, direct measurement and choose appropriate units for reporting various magnitudes. |
| | | | Develop and use systematic procedures for recording and organizing information | |

e) Students will understand and demonstrate the ideas of system, model, change, and scale in exploring scientific and technological matters.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| | Explain how parts are related to other parts in systems (such as cars, computers, and creatures), including how the output from one part of a system (in the form of material, energy, or information) can become the input to other parts. | | | |
| | Estimate the effect of making a change in one part of a system on the system as a whole. | | | Understand how large changes in scale typically change the way things work in physical, biological, or social systems (that is, microcosm versus macrocosm) because the changes in scale affect various properties of those systems in different degrees. |
| | Understand how change in a system can be counterbalanced to maintain equilibrium. | Know how to identify, and discuss, the advantages and disadvantages of several different models could be used to represent the same object. | | |
| | | | | Demonstrate an understanding of physical and temporal scale, based on both mathematics and experience. |

2. EARTH SCIENCE

a) Identify and describe how the earth changes and how humans use and abuse its resources

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| | Explain what causes the seasons | | Explain the factors that influence weather and climate, including the transfer of heat energy, the action of gravitational forces, and the rotation of the Earth. | |
| | | | Describe how weather can be influenced by global climatic patterns, such as El Niño and La Niña. | |
| | Explain the water cycle. | | Describe how human activity can affect weather and climate. | |
| | Describe how soil is formed and how it is modified by living and decaying organisms. | | | |
| | Describe the development, key ideas, and evidence for the theory of plate tectonics | | Identify the origin of local geographic features. | Describe how ideas on the origins and the age of the earth have developed. |
| | Describe the layers of the Earth and their key characteristics, including the movements of the plates that form the crust and the geographic results of those movements | | Explain the phenomena that occur beneath the earth's surface. | |

b) Describe our extraterrestrial environment

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Describe our sun, its place in our galaxy, and the galaxy's place and relative magnitude in the universe. | The phases of the moon are caused by the moon's orbit around the earth, which changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth. | | | Explain the factors that affect the appearance of stars. |
| Describe our solar system, including the planets, the moons, and comets and asteroids. | | | | Compare and contrast the composition, behavior, size, temperature, and age of stars and planets. Describe characteristics of worm holes and black holes, including their genesis and their effect on space and time. |
| | | | | Describe the ancient, Earth-centered understanding of the universe and how Ptolemy's model changed this understanding. |
| | | | | Describe the scientific accomplishments of astronomers and the historical and cultural context and influence of their work. |
| | | | | Explain current scientific theory about the age, origin, and on-going evolution of the universe. |
| | | | | Describe the array of sophisticated technology available to observe the universe and how this has expanded our knowledge of the universe. |

3. LIFE SCIENCE

a) Relate life processes to the structure and function of living things.

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Explain and apply the system used to classify organisms into kingdom, phylum, class, order, family, genus, and species. | | | | |
| Compare and contrast prokaryotes, eukaryotes, and viruses. | | | | |
| Describe responses of plants and animals to various stimuli in their environment. | | | | |
| Discuss the processes and results of asexual reproduction. Discuss the processes and results of sexual reproduction. | | | | |
| | | Describe cell theory. | Identify and discuss the characteristics of the basic elements of living organisms, including carbon, hydrogen, oxygen, and nitrogen. | |
| | | Describe the basic functions of organisms such as respiration, digestion, and excretion, and know that they occur at a cellular level. | Describe the structures and functions of the cell membrane and its involvement in the cell's interaction with its surrounding environment, such as the processes of diffusion, osmosis, active transport, pinocytosis, and phagocytosis. | |
| | | Name the basic cell structures and organelles and identify their functions. | Describe the structures and functions of the basic molecules of living organisms, including water, carbohydrates, fats, and proteins. | |
| | | Compare and contrast plant and animal cells. | | |
| | | <ul style="list-style-type: none"> Know that hereditary information is contained in genes, which are located on chromosomes. Describe Mendel's experiments, including the principle of dominance and recessiveness, the principle of segregation, and the principle of | | <ul style="list-style-type: none"> Describe how an inherited trait of an individual can be determined by one or by many genes, and how a single gene can influence more than one trait. Explain how although each cell |

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| | | <p>independent assortment.</p> <ul style="list-style-type: none"> • Predict genotype and phenotype ratios of possible offspring using a Punnett square for monohybrid and dihybrid crosses. • Know that traits passed from parents to offspring are encoded in segments of DNA molecules called genes. • Describe how selective breeding for particular traits has resulted in new varieties of cultivated plants and domestic animals. | | <p>in an individual has identical genetic information, cells within an individual vary because different portions of the DNA code are activated in different cells.</p> <ul style="list-style-type: none"> • Explain the structure, function, and replication process for DNA. • Know that the genetic code used in DNA molecules is almost the same for all life forms and that the degree of similarity in the DNA sequence can be used to compare how closely organisms are related to each other. • Describe how inserting, deleting, or substituting DNA segments can alter (mutate) genes. • Know that gene mutations can be caused by many factors (such as radiation and chemicals). • Know that a mutated gene may be passed on to every cell that develops from it, but can only be passed on to offspring when the mutation occurs in a sex cell. • Provide examples to show that mutations and new gene combinations may have positive, negative, or no effect on an organism. • Identify and discuss inherited genetic disorders in humans. • Discuss the ethics and implications of genetic engineering. • Describe similarities in human DNA sequences and how they result in similar cell chemistry and anatomy that identify human beings as a single species. • Explain how faulty genes can cause body parts or systems to work poorly. |
| | | Define mitosis and identify its stages | | Define meiosis and identify its stages. |
| | | | | Describe the process of protein synthesis. |

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| | | | | Define cancer and list causes that increase the risk of cancer. |
| Identify and explain how artifacts and preserved remains provide evidence of the physical characteristics and behavior of human beings who lived a very long time ago. | | | | |
| Explain how human similarities enable them to donate blood and organs to one another. | | | | |
| Describe the development of the brain and its functions from birth to death. | Describe the various body changes that occur in human beings from adulthood until death. | Describe the stages of human embryonic development from fertilization to birth. Describe the means by which different contraceptive methods prevent pregnancy | | Explain the relationship between human behavior and cultural, personal, and biological factors. |
| | | | | Explain the necessity of a longer developmental period in humans as compared to other species in terms of the evolution of the human brain. |
| Explain why the level of skill a person can reach in any particular activity depends on innate abilities, practice, and the use of appropriate learning tools and materials. Provide evidence to show that language and tools enable human beings to learn complicated and varied things from others. | | Describe the usual sequence of physical and mental development from birth to adulthood. | | Describe human cognitive ability in terms of life long learning, potential and application to cultural purposes such as art, literature, ritual, and games. |
| Describe the hierarchical organization of living things from cells to organ systems. | Identify hormones as chemicals from glands that affect other body parts and explain how they help the body respond to danger and regulate human growth, development, and reproduction. | | | |
| | Describe modes of transmission and prevention of AIDS and STDs. | | | |
| | Give examples of some viral diseases, such as AIDS, which destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells. | Explain the role of white blood cells and antibodies in the defense of the body against invading microorganisms and viruses. Describe the formation of natural immune responses and artificially induced immune responses and through vaccination. | | |
| | | <ul style="list-style-type: none"> • Describe the digestive process. • Describe the role of the excretory system in the removal of dissolved water molecules • Explain how the skin and lungs | | |

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| | | <p>function in removal of excess body heat.</p> <ul style="list-style-type: none">• Describe the composition and pathways of the circulatory system. | | |
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b) Connect factors that influence the ways organisms live together – past, present and future

| Grade 6 | Grade 7 | Grade 8 | Grade 9 | Grade 10 |
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| Define the terms individual, population, community, and biome and provide examples of each. | | | | |
| List and describe ways living organisms interact with the abiotic factors in an ecosystem. | | | Explain how the carrying capacity of an ecosystem may change as availability of resources changes. | |
| Describe and provide examples demonstrating negative and positive relationships among organisms, such as predator/prey. | | | | |
| Compare and contrast physical and behavioral adaptations to changes in an organism's environment. | | | | |
| Know that matter recycles within ecosystems and that although the form of matter changes, the total amount remains constant. | | | Discuss sources and sinks in matter and energy cycles. | |
| Diagram and discuss cycles in ecosystems including water, carbon, and nitrogen | | | Diagram and explain trophic levels in an ecosystem. Describe the laws of thermodynamics and apply the principles to an ecosystem Describe photosynthesis and know that it occurs at a cellular level. | |
| Explain why some organisms may survive changes and others may not | | | | Explain how variation within a species increases the chances of survival of the species under changing environmental conditions |
| Identify several kinds and causes of air, land, and water pollution. | | | | |
| Describe the impact of pollution to living organisms and to the environment. | | | | Explain how the great diversity of species increases the chance that at least some living organisms will survive in the event of major global changes. |
| Propose methods of reducing and controlling pollution. | | | Understand how monitoring environmental factors assists scientists in determining the health of the environment (such as soil, air, or water conditions). | |

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| Describe positive and negative ways humans can affect ecosystems. | Explain the influence of sanitation, diet, medication, gender, genes, environmental conditions and personal behaviors on length and quality of life. | | Give examples of natural and human-initiated environmental changes that may influence levels of harmful substances. | |
| | | | Define the impact of immigration, emigration, birth rate, and death rate on population size. | |
| | | | Identify the factors that control population fluctuations in a given ecosystem leading to a rough state of equilibrium. | |
| | Understand the history of disease, including the development of germ theory and its role in the development of knowledge of how to strengthen the immune system and cure infections. | | Describe stages of succession that occurs leading to a climax community. | |
| Describe the environmental conditions that lead to the slow formation of fossil fuels and know that by burning these fossil fuels heat, carbon dioxide, and other gases are released into the environment. | | | | |
| Define the phrase "survival of the fittest" and relate it to the process of natural selection. | | | | Explain Darwin's theory of natural selection. Understand how the work of other scientists (for example, Mendel, et al) supports Darwin's theory. |
| Know that small differences between parents and offspring can accumulate through successive generations, so descendants are different from their ancestors | | | | |
| Define biological evolution as the process whereby the earth's present-day species developed from earlier species. | | | | Describe various scientific theories explaining the origin of life on Earth. Evaluate evidence supporting biological evolution, including morphological, anatomical, and molecular features of fossils and living organisms. Describe patterns of evolution (i.e., divergent, convergent, and coevolution). |
| Understand how selective breeding influences the process of evolution. | | | | Discuss the results of sexual and asexual reproduction in terms of species diversity. |

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| | | | | Explain biological and morphological characteristics used to define a species. |

4. CHEMICAL SCIENCE

a) Model and describe the structures, properties and uses of substances

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| | Recount the evolution in thought about elements, from ancient ideas (e.g., the Greeks' four element and the Chinese' five elements) to the modern knowledge of over 100 elements. | | | Describe the development and organization of the periodic table and use it to predict characteristics of elements. |
| | Understand basic facts about atoms, including their submicroscopic size, their uniqueness in each element, and their capacity to organize into molecules. | Describe the structure of atoms, and how the number of protons, neutrons, and electrons determine their properties. | | Describe the work of early scientists in the evolving model of the atom. Describe the work of John Dalton concerning elements, atoms, compounds, and molecules and how he explained reactions in quantitative terms. |
| | Explain the relationship between the energy of atoms and molecules and the state of matter. | | | Describe the particles and forces that make up electrons, neutrons, and protons. Understand that ions are formed by the gain or loss of electrons. |
| | | | | Explain how molecular and ionic structure determine the properties of substances. |

b) Comprehend and explain chemical change

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| | | Understand that many substances dissolve in water, which can greatly facilitate reactions between them. | | Identify types of chemical reactions, write balanced equations, and perform simple stoichiometric calculations. |
| | | Understand that reaction rates are influenced by a number of factors, such as | | |

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| | | temperature. | | |
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5. PHYSICAL SCIENCE

a) Understand energy; what it is and how it is used

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| | | Understand that energy cannot be created or destroyed but only changed from one form into another. | | |
| | | Give examples of several processes from life science, physical science and earth science in which energy is transformed into another form. | | |
| | | Describe the different forms in which energy can appear, including heat energy, chemical energy, mechanical energy, and gravitational energy. | | |
| | | Show that heat can be transferred through materials by the collisions of atoms or across space by conduction, convection, and radiation. | Understand that transformations of energy usually produce some energy in the form of heat. | |
| | | When warmer objects are put with cooler ones, the warm ones lose heat and the cool ones gain it until they all reach the same temperature. | | |
| | | Heat moves from one object to another at different rates, depending on a variety of factors. | Describe the concept of entropy and the principles related to it. | Explain the law of conservation of matter and energy. |
| Explain how electricity can be produced, distributed and transformed into useful forms. | | | | |
| Describe attempts in various parts of the world tries to conserve fossil fuels or uses alternate forms of energy to slow the depletion of resources, reduce pollution, or save money. | | | Assess the advantages and disadvantages of using nuclear energy. | |
| Compare the environmental consequences of producing, distributing, and transforming various forms of energy. | | | Evaluate the impact of industry on our society and environment in terms of energy use. | |
| | | Understand that vibrations, such as sound and earthquakes, set up wavelike disturbances that spread away from the source and move at different speeds in different materials | | Describe the Doppler effect. |
| | | Understand that waves carry energy from | | |

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| | | one place to another | | |
| | | Identify transverse and longitudinal waves in mechanical media such as springs, ropes, and seismic waves in the Earth. | | |
| | | Explain different wave phenomena such as reflection and refraction | | |
| | | Solve problems involving wavelengths, frequency, and wave speed. | | |
| | | Understand that sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates. | | |
| | | Understand that radio waves, visible light, and x-rays are different wavelength bands in the spectrum of electromagnetic waves. | | |

b) Explain what forces are, their effects and how they can be used

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| Explain what a force is. | Show through calculations that the force on a body is the sum of all forces acting on it. | | | |
| | Identify forces acting on an object, including gravity, elastic forces, and friction. | | | |
| | Demonstrate that the greater the mass of an object the more force is needed to achieve the same change in motion. | | | |
| | Show that when the forces on an object are balanced, the motion of the object does not change. | | | |
| | Understand that when the forces on an object are unbalanced, the object will change its motion. | | | |
| | Apply Newton's three laws of motion to predict the motion of most objects. | | Explain the law of universal gravitation, as well as Newton's laws of motion, and account for their acceptance even after Einstein's theories of relativity. | Show that gravity is a function of mass and distance. |
| Explain what causes the planets to move in circular orbits around the Sun. | | | | |
| | Understand magnetic fields and why not all materials are magnetic. | | | |
| | Show how magnetic forces can be produced with moving electric charges using fluctuating magnetic fields. | | Identify and interrelate the variables affecting the flow of electricity. | |