Singapore American School **High School Science Curriculum: Biology**

Standard 1: Life Science

As a basis for understanding Life Science, students will develop the following knowledge, skills and understandings:

1.1 Students understand the principles of heredity and related concepts.

1.1.1 Describe the structure of DNA and relate this to its function (genetic code).
- 1.1.1.1 Analyze and compare the degree of similarity in the DNA sequence between different species/individuals.
- 1.1.1.2 Explain the processes of DNA replication, and protein synthesis.
- 1.1.1.3 Deduce the primary structure of a polypeptide chain when given a DNA template.

1.1.2 List and label the major stages of Mitosis.
- 1.1.2.1 Compare and contrast Mitosis and Meiosis.
- 1.1.2.2 Demonstrate an understanding of how genetic variation is obtained during Meiosis (recombination and independent assortment).

1.1.3 Define mutation with respect to the genetic code.
- 1.1.3.1 Describe how the deletion or substitution of nucleotides in the DNA template can lead to a point mutation. Give an example of such a mutation. List some of the contributing factors that increase the risk of some forms of cancer.
- 1.1.3.2 Account for the difference in heritability between a gamete mutation and somatic cell mutation.
- 1.1.3.3 Identify and discuss some inherited genetic disorders in humans.
- 1.1.3.4 Discuss the ethics and implications of genetic engineering.

1.1.4 Demonstrate a functional understanding of the following concepts in Mendelian genetics:
- 1.1.4.1 Dominant and recessive traits, monohybrid crosses, dihybrid crosses, sex linkage, pedigree.

1.2 Students understand the structure and function of cells and organisms.

1.2.1 Identify the structures of different types of cell parts (e.g., cell wall, cell membrane, cytoplasm, cell organelles such as the nucleus, chloroplast. Mitochondrion, Golgi apparatus, vacuole) and explain the functions they perform (e.g., transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal).

1.2.2 Understand the chemical reactions involved in cell functions:
- 1.2.2.1 Food molecules taken into cells are broken down to provide the chemical constituents needed to synthesize other molecules.
- 1.2.2.2 Enzymes facilitate the breakdown and synthesis of molecules.

1.2.3 Describe the process of photosynthesis and respiration in plants:
- 1.2.3.1 Chloroplasts in plant cells use energy from sunlight to combine molecules of carbon dioxide and water into complex, energy-rich organic compounds and release oxygen to the environment.
- 1.2.3.2 Mitochondria break down energy rich molecules into simpler molecules of carbon dioxide and water, releasing useable energy in the process.

1.2.4 Explain how cells functions are regulated through selective gene expression, protein production and activity, and controls of cell growth and division.

1.2.5 Understand that the complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

1.2.6 Explain the processes of cell division and differentiation:
- 1.2.6.1 Meiosis forms gametes that provide for sexual reproduction and species diversity to occur.
- 1.2.6.2 Mitosis forms somatic cells allowing organisms to asexually reproduce, grow and repair tissues.
- 1.2.6.3 DNA replication allows for copies of the genome to be provided from one generation to the next cell generation.
- 1.2.6.4 Cell differentiation provides specialization and compartmentalization within an organism's tissues and organ systems.
- 1.2.6.5 Errors in cell replication and division can lead to changes in cellular activity.

1.2.7 Discern differences in the levels of protein structure and functions of proteins in cell processes.
- 1.2.7.1 Proteins are long, usually folded polypeptide chain molecules made of specific sequences of amino acids coded by DNA.
- 1.2.7.2 Protein structures, dictated by the gene sequence, provide for most of the molecular work occurring in the cell.

1.2.8 Understand specialized cells comprise tissues that form organs and organ systems for a specific function.
- 1.2.8.1 Tissues are a group of cells having a common function.
- 1.2.8.2 Organs are a group of tissues with a function specific to an organ system.

1.3 Students understand relationships among organisms and their physical environment.

1.3.1 Discern between organized and disorganized states of matter (as they apply to living systems).
- 1.3.1.1 The Sun is the ultimate source of energy for ecosystems.
- 1.3.1.2 The input of the Sun's energy is constantly required for living systems to maintain organization and to function properly.

1.3.2 Compare and contrast the interrelationships/interdependencies that help generate stable ecosystems.
- 1.3.2.1 Population sizes are constrained by the lack of abiotic factors (water for example) in an ecosystem.
- 1.3.2.2 Healthy ecosystems are maintained by a myriad of interdependent relationships between the various species living together.

1.3.3 Estimate the amount of life an ecosystem can support if given the amount of matter and energy present.
- 1.3.3.1 The recycling of matter and energy are essential for ecosystems.
- 1.3.3.2 Energy is lost at various levels of organization in an ecosystem.

1.3.4 Classify how chemical elements are recombined into new states of matter as they flow through different levels of organization in ecosystems.
- 1.3.4.1 Chemical elements such as nitrogen and carbon are constantly being combined to form new states new compounds as they flow through the different levels of organization in an ecosystem.

1.3.5 Evaluate the various ways humans have altered the equilibrium of ecosystems causing potentially irreversible effects.
- 1.3.5.1 Historically humans have impacted ecosystems through various ways including overconsumption of resources, pollution, misapplied technology (and others) which often have negative impacts on ecosystems.
- 1.3.5.2 Humans have the capability of creating more sustainable ways of living which will have far less negative impact on ecosystems.

1.4 Students understand biological evolution and the diversity of life.

1.4.1 Show that heritable characteristics, which can be biochemical and anatomical, largely determine what capabilities an organism will have, how it will behave, and how likely it is to survive and reproduce.

1.4.2 Understand the concept of natural selection:
- 1.4.2.1 When an environment changes, some inherited characteristics become more or less advantageous or neutral.

1.4.2.2 Change alone can result in characteristics having no survival or reproductive value;
1.4.2.3 This process results in organisms that are well suited for survival in particular environments.

1.4.3 Comprehend how variation of organisms within a species increases the chance of survival of the species, and how the great diversity of species on earth increases the chance of survival of life in the event of major global changes.

1.4.4 Explain that the basic idea of evolution is that the earth's present-day life forms have evolved from earlier, distinctly different species as a consequence of the interactions of:
1.4.4.1 The potential for a species to increase its numbers.
1.4.4.2 The genetic variability of offspring due to mutation and recombination of genes.
1.4.4.3 A finite supply of the resources required for life.
1.4.4.4 The ensuing selection by the environment of those offspring better able to survive and leave offspring.

1.4.5 Understand the history of the origin and evolution of life on earth:
1.4.5.1 Life on earth is thought to have begun 3.5 – 4 billion years ago as simple, unicellular organisms.
1.4.5.2 Cells with nuclei evolved about a billion years ago, after which increasingly complex multicellular organisms evolved.

1.4.6 Identify how natural selection and its evolutionary consequences provide a scientific explanation for the diversity and unity of past and present life forms on earth:
1.4.6.1 Recurring patterns of relationship exist throughout the fossil record.
1.4.6.2 Molecular similarities exist among the diverse species of living organisms; the millions of different species living today appear to be related by descent from common ancestors.

1.4.7 Demonstrate how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships:
1.4.7.1 Shared derived characteristics inherited from a common ancestor.
1.4.7.2 Degree of kinship estimated from the similarity of DNA sequences.

Standard 2: Physical Science

As a basis for understanding Physical Science, students will develop the following knowledge, skills and understandings:

2.1 Students understand the structure and the properties of matter.

2.1.1 Know that chemical reactions can be accelerated by catalysts:
2.1.1.1 Enzymes
2.1.1.2 Metallic surfaces

2.2 Students understand chemical reactions.

2.3 Students understand the sources and properties of energy.

2.4 Students understand forces and motion.

2.5 Students understand waves and optics.

2.6 Students understand electricity and magnetism.

Standard 3: Earth and Space Science

No standards apply.

Standard 4: Nature of Science

As a basis for understanding the nature of science as it relates to scientific knowledge, scientific inquiry, and scientific enterprise and to address content in the other standards students will:

4.1 Apply proper scientific measures when solving problems.

4.1.1 Know and employ metric units when measuring and problem solving:
- 4.1.1.1 Identify the seven major SI and laboratory metric units, i.e., meter, kilogram, second, ampere, Kelvin, mole, and candela.
- 4.1.1.2 Convert between prefixes nano to mega within the metric system.
- 4.1.1.3 Differentiate and convert between the two temperature scales; Celsius and Kelvin.
- 4.1.1.4 Contrive and solve derived values (volume and density) using correct SI units.

4.1.2 Use problem solving strategies (including dimensional analysis) to solve mathematical problems:
- 4.1.2.1 Identify the potentially important information given in a problem when choosing an appropriate solution
- 4.1.2.2 Determine the true question and/or conceptual premise; applying appropriate units when applicable
- 4.1.2.3 Properly manipulate conversion factors to dimensional analysis questions

4.1.3 Reason sources of error when discussing accuracy and precision (uncertainty) of results; examples include human, instrumental, systematic, and random errors:
- 4.1.3.1 Reason the number of significant digits, accuracy, and precision in problems and laboratory tools.
- 4.1.3.2 Answer mathematical operations using scientific notation

4.1.4 Demonstrate safety procedures within lab situations:
- 4.1.4.1 Demonstrate proper lab safety.
- 4.1.4.2 Locate and explain how to properly use safety equipment in the lab.

4.1.5 Use technology and mathematics (e.g., measurement, formulas, charts, graphs) to perform accurate scientific investigations and communications.
- 4.1.5.1 Use appropriate lab tools, measuring devises, calculators, computers, Probeware, etc. correctly during investigations
- 4.1.5.2 Utilize appropriate measurements, formulas, charts, graphs, etc. when analyzing laboratory data

4.2 Investigate the natural world using scientific inquiry.

4.2.1 Effectively contribute to a collaborative group; including accepting roles, following norms, and successfully communicating.

4.2.2 Design and conduct open ended scientific investigations; confirming scientific laws, theories, and models; or to explore new aspects of the natural world and new areas of science.

4.2.3 Devise investigations that:
- 4.2.3.1 Identify a focused problem or research question
- 4.2.3.2 Formulate testable hypotheses that relate to the research question; supporting it quantitatively when appropriate
- 4.2.3.3 Select relevant independent and dependent variables
- 4.2.3.4 Identify and clarify the method and controls; using appropriate apparatus
- 4.2.3.5 Demonstrate competence in using laboratory equipment (seeking assistance when required); paying attention to safety issues
- 4.2.3.6 Adapt to new and unforeseen circumstances while following instructions
- 4.2.3.7 Employ methods that collect sufficient and relevant quantitative and/or qualitative data; using appropriate units
- 4.2.3.8 Organize and display raw data for easier interpretation and analysis data
- 4.2.3.9 Determine errors, their quantitative/qualitative effects they have on results, and calculate percent error when possible
- 4.2.3.10 Formulate a conclusion based on interpretation of results with an explanation, and, where appropriate, compare results with literature values
- 4.2.3.11 Receive critical response from others

4.2.4 Reason that when conditions of an investigation cannot be controlled, it may be necessary to discern patterns by observing a wide range of natural occurrences.

4.2.5 Know that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.

4.2.6 Comprehend why scientists conduct investigations:
- 4.2.6.1 To discover new aspects of the natural world
- 4.2.6.2 To explain recently observed phenomena
- 4.2.6.3 To test the conclusions of prior investigations
- 4.2.6.4 To test predictions of current theories

4.2.7 Appreciate that investigations and public communication among scientists must meet specific criteria in order to be accepted as new knowledge and methods:
- 4.2.7.1 Strive for certainty of proposed solutions using experimental standards
- 4.2.7.2 Formulate logical arguments are and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge
- 4.2.7.3 Convey explanations with logical structure and rules of evidence
- 4.2.7.4 Show commitment to making public their methods, procedures and conclusions

4.2.7.5 Methods and procedures used to obtain evidence are clearly reported to enhance opportunities for further investigation
4.2.7.6 Understand the logical and empirical communication among scientists and the public leads to new accountable information
4.2.7.7 Continually test, revise, and occasionally discards theories, therefore allow for continual critical response from others
4.2.7.8 Know that all current scientific knowledge in principle is subject to change, as new evidence becomes available

4.2.8 Understand the Nature of Science Inquiry is driven by the desire to understand the natural world and seeks to answer questions that may or may not directly influence humans.

4.3 Evaluate the acquisition, development, and modification of scientific knowledge in the past, present, and future.

4.3.1 Know ways in which science distinguishes itself from other bodies of knowledge, through use of empirical standards and logical arguments

4.3.2 Be aware that scientific explanations must meet certain criteria to be considered valid:
4.3.2.1 Must be consistent with experimental and observational evidence about nature
4.3.2.2 Make accurate predictions about systems being studied
4.3.2.3 Be logical
4.3.2.4 Respect rules of evidence
4.3.2.5 Be open to criticism
4.3.2.6 Report methods and procedures
4.3.2.7 Make a commitment to making knowledge public

4.3.3 Reason how scientific knowledge changes and accumulates over time:
4.3.3.1 All scientific knowledge is subject to change as new evidence becomes available
4.3.3.2 Some scientific ideas are incomplete and opportunity exists in these areas for new advances
4.3.3.3 Scientific knowledge is continually tested, revised, and occasionally discarded as new evidence is obtained

4.3.4 Accept and anticipate that from time to time, major shifts occur in the scientific view of how the world works, but usually the changes that take place in the body of scientific knowledge are usually small modifications of prior knowledge.

4.4 Examine how science and its enterprises impact society.

4.4.1 Compare and contrast Science and Technology.

4.4.2 Reflect that, throughout history, diverse cultures have developed scientific ideas and solved human problems through technology.

4.4.3 Understand that individuals and teams contribute to scientific knowledge and understanding at different levels of complexity:
4.4.3.1 Conducting basic field studies or improving advanced technology
4.4.3.2 Creating New Technologies
4.4.3.3 Solving technological problems
4.4.3.4 Collaborating (sometimes between hundreds of people) on a major scientific question or technological problem

4.4.4 Comprehend the free and rapid interplay of theoretical ideas and experiments results in published scientific literature maintains crucial links between scientific fields.

4.4.5 Develop information and technology skills which are essential in modern scientific endeavors.

4.4.6 Appreciate that progress in Science/Technology can relate to social issues and challenges (e.g., funding priorities, health problems)

4.4.7 Understand that there are ethical traditions associated with the scientific enterprise:
- 4.4.7.1 Be committed to peer review
- 4.4.7.2 Report truthfully about methods and outcomes of investigations
- 4.4.7.3 Publish results of work with the expectation of peer review
- 4.4.7.4 Scientists who violate these traditions are censored by their peers

4.4.8 Consider that scientists and engineers can only conduct research on human subjects or stem cells if they have the consent of the subjects or governing bodies.

4.4.9 Accept that technology is often driven by the desire to help meet human needs, solve human problems, and fulfill human aspirations.

4.4.10 Be able to assess a proposal from a scientific enterprise; including questions about: alternatives, risks, costs, benefits, consideration of who benefits, who suffers, who pays, who gains, and who bears the risks.

4.4.11 Validate that credible technological resources come from professional presentations, journal publications, and data bases.

4.4.12 Understand that science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen.

4.4.13 Acknowledge science is interdependent on different fields of study in different disciplines.
- 4.4.13.1 Scientists in different disciplines ask different questions, use different methods of investigation and accept different types of evidence to support their explanations.
- 4.4.13.2 Many scientific investigations require the contributions of individuals from different disciplines
- 4.4.13.3 New disciplines of science (such as geophysics, biochemistry, and genomics) often emerge at the interface of older disciplines

4.4.14 Undergo searches for current areas where data, information, and understanding are incomplete; therefore providing the best opportunity for students to advance in the science related career opportunities

4.4.15 Comprehend that creativity, imagination, and a good knowledge base are all required in the work of science and engineering

4.5 Students understand the connections among science, global issues and sustainable solutions.

As a basis for this, students will understand:

4.5.1 Climate Change (Global Warming)

4.5.2 Biodiversity and Ecosystem Losses

4.5.3 Fisheries Depletion

4.5.4 Deforestation

4.5.5 Water Deficits

4.5.6 Air, Water and Soil Pollution

4.5.7 Global Infectious Diseases

4.5.8 Natural Disaster Prevention and Mitigation

4.5.9 Human Population Dynamics

4.5.10 Unsustainable Land Use (unsustainable agriculture, livestock grazing, urban sprawl, landfills, hazardous waste, mining and mineral extraction)

4.5.11 Solid Waste Management (waste minimization, recycling, closed loop systems)

4.5.12 Energy Conservation, alternative energy, alternative fuels