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 its related concepts.

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

1.2.1 Understand the characteristics of the Kingdom of Protozoa.

1.2.1.1 Distinguish and compare the major features of the following phyla:

1.2.1.1.1 Phylum- Sarcomastigophora (The Amoeba)
1.2.1.1.2 Phylum- Ciliophora (The Paramaecium)
1.2.1.1.3 Phylum- Euglenozoa (The Euglena)

1.2.1.2 Use light microscopes to investigate living examples of the above phyla using light microscopes.
1.2.1.3 Understand the nature and extent of the global disease malaria.
1.2.1.4 Explain in detail the life cycle of the Plasmodium parasite.
1.2.1.5 Explain the transmission of malaria and relate this to current methods of eradication and control.

1.2.2 Understand the characteristics of the Phylum Porifera – “the sponges.”

1.2.2.1 Appreciate that sponges are the simplest multicellular organism and understand how they are classified (using spicules).
1.2.2.2 Draw/label and/or describe how a sponge filter feeds.

1.2.3 Understand the characteristics of the Phylum Cnidaria.

1.2.3.1 Describe the general form and function of medusa and polyp life forms.
1.2.3.2 Investigate structure and locomotion in the Class Hydrozoa – Hydra in a laboratory practical.
1.2.3.3 Know the structure and life cycle of the Box jellyfish and be able to construct a visual mind map of its ecological niche.

1.2.4 Understand the characteristics of the Phylum Platyhelminthes (the flatworms) and Phylum Nematoda (the roundworms).

1.2.4.1 Observe and describe the behavior of a planarian during a laboratory practical.
1.2.4.2 Explain (in general terms) and give specific examples of each of the following endoparasitic adaptations:

1.2.4.2.1 Reproductive: adaptations that would enable parasites to be highly successful in infecting the host species and/or dispersing its eggs.
1.2.4.2.2 Nutritional: adaptations that would enable parasites to be highly successful feeders in the digestive system of another animal.
1.2.4.2.3 Behavioral: adaptations in either the parasites behavior or in the way that the parasite changes the hosts behavior, that help it be successful in its mode of life.
1.2.4.2.4 Structural: physical adaptations that a parasite has to help it be successful in its mode of life.

1.2.4.3 Investigate the life cycle and ecological niche of an endoparasitic worm that infects humans and communicate findings.

1.2.5 Understand the characteristics of the Phylum Mollusca.

1.2.5.1 Know the general distinguishing features of the following classes:

1.2.5.1.1 Bivalvia

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<table>
<thead>
<tr>
<th>1.2.5.1.2</th>
<th>Cephalopoda</th>
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<tbody>
<tr>
<td>1.2.5.2</td>
<td>Dissect and identify the main external and internal features of the clam during a laboratory practical.</td>
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<td>1.2.5.3</td>
<td>Know that a symbiotic relationship exists between the giant clam and algae cells living in its mantle tissue.</td>
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<td>1.2.5.4</td>
<td>Understand how a clam feeds and be able to communicate this in terms of structure and function.</td>
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<td>1.2.5.5</td>
<td>Make a biologically accurate drawing of the external features of the squid during a laboratory practical.</td>
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<tr>
<td>1.2.5.6</td>
<td>Understand how a squid moves and be able to communicate this in terms of structure and function.</td>
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<tr>
<td>1.2.5.7</td>
<td>Understand the definition of animal intelligence and be able to comment on invertebrate intelligence with respect to the octopus.</td>
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**1.2.6** Understand the characteristics of the Phylum Arthropoda.

- **1.2.6.1** Understand that Arthropods have been able to achieve great diversity and abundance due to key structural features and life cycle changes.
  - **1.2.6.1.1** With reference to the class Insecta, be able to accurately explain in detail (using the appropriate and correct biological terms and labeled diagrams) the following topics: How insects breathe, breed and feed.
- **1.2.6.2** Make long term observations of a local insect (the lime butterfly) as it undergoes complete metamorphosis.
- **1.2.6.3** Make an accurate biological drawing of a Lubber grasshopper during a laboratory practical.
- **1.2.6.4** Dissect and identify the mouthparts of the Lubber grasshopper during a laboratory practical.
- **1.2.6.5** Design and carry out an investigation into the taxic responses of a living Arthropod (shrimp or mealworms) during a laboratory practical.
- **1.2.6.6** Accurately explain how bees communicate distance and direction to a food source.
- **1.2.6.7** Create a biologically accurate (with respect to scale and color) model of a named insect species. Research the ecological niche of this insect species and communicate findings.

**1.2.7** Understand the characteristics of the Phylum Annelida (segmented worms).

- **1.2.7.1** List the general features of the following three Classes:
  - **1.2.7.1.1** Oligochaeta (earthworms)
  - **1.2.7.1.2** Polychaeta (marine worms)
  - **1.2.7.1.3** Hirudinidae (Leeches)
- **1.2.7.2** Make general observations on the behavior and locomotion of living earthworms during a laboratory practical.
- **1.2.7.3** Know why the medicinal leech (Hirudo medicinalis) is of importance to humans.

**1.2.8** Understand the characteristics of the Phylum Echinodermata.

- **1.2.8.1** List and describe some general features of the following Classes:
  - **1.2.8.1.1** Class Asteroidea
  - **1.2.8.1.2** Class Ophiuroidea
  - **1.2.8.1.3** Class Echinoidea
  - **1.2.8.1.4** Class Holothuroidea

**1.2.9** Understand the characteristics of the Phylum Chordata.

- **1.2.9.1** Know what a notochord is and why it is of evolutionary importance.
- **1.2.9.2** Know that there are 3 main classification “groups” of fish and know the general features of each group:
  - **1.2.9.2.1** Super class - Agnatha
  - **1.2.9.2.2** Class- Chondrichthyans
1.2.9.3 Explain the importance of the Class Sardopterygii – the "lobe-finned fish" to evolutionary biologists.
1.2.9.4 Explain in detail both the structure and function of the following: Gills, swim bladder, lateral line system.
1.2.9.5 Use observations of the external anatomy and major internal organs of a bony fish to make an accurate biological drawing during a laboratory practical.
1.2.9.6 Design and carry out an investigation into the relationship between breathing rate and temperature in a living bony fish during a laboratory practical.
1.2.9.7 Read a scientific paper that explores the importance of salmon to the ecology of North American forests and effectively interpret and communicate the key ideas found within this article.
1.2.9.8 Observe fish behavior during an independent fieldwork.

1.2.10 Understand the characteristics of the Class Amphibia.
1.2.10.1 Know the general features of the following 3 orders:
    1.2.10.1.1 Anura – Frogs & Toads
    1.2.10.1.2 Urodela – Salamanders
    1.2.10.1.3 Apoda - Caecilians
1.2.10.2 Observe the general external and internal features of the frog. Make an accurate biological drawing of the internal anatomy of the frog in a laboratory practical.
1.2.10.3 Use the dissecting microscope to classify tadpole larva into different life stages in a laboratory practical.

1.2.11 Understand the characteristics of the Class Reptilia.
1.2.11.1 Know that reptiles were the first vertebrate group to make the complete transition to land for the following reasons: the amniotic egg, waterproof skin and limb modification.
1.2.11.2 Know the general and distinguishing features for each of the following orders:
    1.2.11.2.1 Sphenodonta
    1.2.11.2.2 Testudines (Chelonia)
    1.2.11.2.3 Crocodilia
    1.2.11.2.4 Squamata
1.2.11.3 Understand and be able to describe how each of the following adaptations have enabled the snakes to become a highly specialized and successful group in terms of feeding, sensing and locomotion.
1.2.11.4 Be able to explain some of the current evidence on dinosaur extinction theory.

1.2.12 Understand the characteristics of the Class Aves.
1.2.12.1 Know that Archaeopteryx is an important transition fossil that links reptiles and birds and describe some of the key transition features of this species.
1.2.12.2 Understand that the evolution of “warm-bloodedness” or Endothermy has enabled birds to survive in virtually every known environment.
1.2.12.3 Explain the structure and function of hollow bones and air sacs, a “keeled” sternum bone, flight feathers as key avian features.
1.2.12.4 Analyze actual experimental data and generate a supported conclusion that answers the question, "Why do male Emperor penguins huddle in groups?"

1.2.13 Understand the characteristics of the Class Mammalia.
1.2.13.1 List the key characteristics of mammals with particular reference to vivipary.
1.2.13.2 Compare and contrast the reproductive systems of the following mammalian groups:
1.2.13.2.1 Monotremata
1.2.13.2.2 Marsupialia
1.2.13.2.3 Eutheria
1.2.13.3 Understand that Eutherian mammals (placental mammals) have undergone adaptive radiation to become a hugely diverse and successful group.
1.2.13.4 Carry out an independent investigation into the ecological niche of a named mammal species, investigating both the biological and ecological aspects this species.
1.2.13.5 Make up an ethnogram (record of behavior) for a mammalian species (primate).

1.3 Students understand relations among organisms and their physical environment.

1.4 Students understand biological evolution and the diversity of life.
1.4.1 Understand and appreciate factors that have shaped and contributed to the biological diversity of life on earth, specifically the role of extinction, natural selection, sexual selection, ecological niche and competition.
1.4.1.1 Construct a biological timeline of life on earth that identifies major geological time periods and clearly shows the relationship between the evolution of different animal groups and plants.
1.4.1.2 Explain how different types of fossils form, how they are dated (absolute and relative dating) and how fossils can lead to a more complete understanding of the ecological niche of an extinct animal.
1.4.1.3 Determine the ecological niche differences of barn owls' from different geographic locations using owl pellets during laboratory practical.
1.4.1.4 Understand the importance of the work of both Charles Darwin and Alfred Wallace in the development of the theory of natural selection, explaining in detail how the process of natural selection works.
1.4.1.5 Understand and be able to use Binomial Nomenclature correctly. (Know the seven major categories or classification taxa.)
1.4.1.6 Create and use a dichotomous key to correctly identify local insects.

Standard 2: Physics Science

No standards apply.
# 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 Contribute and solve derived values (volume and density) using correct SI units.  
  - 4.1.1.5 Use problem solving strategies (including dimensional analysis) to solve mathematical problems.  
  - 4.1.1.6 Identify the potentially important information given in a problem when choosing an appropriate solution.  
  - 4.1.1.7 Determine the true question and/or conceptual premise; applying appropriate units when applicable.  
  - 4.1.1.8 Properly manipulate conversion factors to dimensional analysis questions.  
  - 4.1.1.9 Calculate the actual size (using S.I. units of length) of unicellular protozoa.  
  - 4.1.1.10 Calculate the magnification of a biological drawing.
- **4.1.2** Reason sources of error when discussing accuracy and precision (uncertainty) of results; examples include human, instrumental, systematic, and random errors.  
  - 4.1.2.1 Reason the number of significant digits, accuracy, and precision in problems and laboratory tools.  
  - 4.1.2.2 Answer mathematical operations using scientific notation.
- **4.1.3** Demonstrate safety procedures within lab situations:  
  - 4.1.3.1 Demonstrate proper lab safety.  
  - 4.1.3.2 Demonstrate correct and safe use of scalpel, dissecting scissors, blunt and sharp probe, tweezers  
  - 4.1.3.3 Locate and explain how to properly use safety equipment in the lab.
- **4.1.4** Use technology and mathematics (e.g., measurement, formulas, charts, graphs) to perform accurate scientific investigations and communications.  
  - 4.1.4.1 Use appropriate lab tools, measuring devises, calculators, computers, Probeware, etc. correctly during investigations.

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*Singapore American School, January 14, 2009*
4.1.4.2 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 Arguments are logical 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

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4.4.3 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

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## 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