Your Living Curriculum©

General Guide-Lines and Instructions for submission (GGL&I)

Submission No:

There is one general guideline for all grade levels in high school, ninth through twelfth. This outline will give you an idea of good instructional content. It's our hope that you will have the best chance of getting your work accepted. Keep writing!

Level	**Concepts & Topics**
High School	**Physical Science**

Physical science encompasses physical and chemical sub-processes that occur within systems. At the high school level, students gain an understanding of these processes at both the micro and macro levels through the intensive study of matter, energy, and forces.[4] Students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of causes, effects, and solutions for physical processes in the real world. The essential standards are those that every high school student is expected to know and understand. Plus standards in chemistry and physics are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses. It is suggested to use the metric system within measurement.

Each **atom** has a charged substructure consisting of a **nucleus**, which is made of **protons** and **neutrons**, surrounded by **electrons**. The **periodic table** orders elements horizontally by the number of protons in the atom's nucleus and places those with similar **chemical properties** in columns. The repeating patterns of this table reflect patterns of **outer electron states**. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **Stable** forms of matter are those in which the electric and magnetic field energy is minimized. Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.

Chemistry

Chemical processes, their **rates**, and whether or not **energy** is **stored** or **released** can be understood in terms of the **collisions** of **molecules** and the rearrangements of **atoms** into new molecules, that are matched by changes in **kinetic energy**. In many situations, a dynamic and condition-dependent balance between a **reaction** and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are **conserved**, together with knowledge of the **chemical properties** of the elements involved, can be used to describe and predict chemical reactions.
Scientific understanding can help to identify implications of certain applications but decisions about whether certain actions should be taken will require **ethical and moral judgements** which are not provided by knowledge of science. There is an important difference between the understanding that science provides about, for example, the need to preserve biodiversity, the factors leading to climate change and the adverse effects of harmful substances and lifestyles, and the actions that may or may not be taken in relation to these issues. Opinions may vary about what action to take but arguments based on scientific evidence should not be a matter of opinion. The total number of neutrons plus protons does not change in any **nuclear process**. Strong and weak nuclear interactions determine nuclear stability and processes. Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials from the isotope ratios present.

Physics

Newton's law of universal gravitation and **Coulomb's law** provide the mathematical models to describe and predict the effects of **gravitational** and **electrostatic forces** between distant

objects. Forces at a distance are explained by fields permeating space that can transfer energy through space. **Magnets** or changing electric fields cause **magnetic fields**; **electric charges** or changing magnetic fields cause **electric fields**.
Some cases of action at a distance are not explained in terms of radiation from a source to a receiver. A magnet, for example, can attract or repel another magnet and both play equal parts. Similarly, the attraction and repulsion between electric charges is reciprocal. The idea of a field is useful for thinking about such situations. A field is the region of the object's influence around it, the strength of the field decreasing with distance from the object. Another object entering this field experiences an effect – attraction or repulsion. Gravity, electric and magnetic interactions can be described in terms of fields.
Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. **Momentum** is defined for a particular frame of reference; it is the **mass** times the **velocity** of the object. In any system, total momentum is always **conserved**. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. The application of science in making new materials is an example of how scientific knowledge has led advances in technology and provided engineers with a wider choice in designing constructions. At the same time technological advances have helped scientific developments by improving instruments for observation and measuring, automating processes that might otherwise be too dangerous or time consuming to undertake, and particularly through the provision of computers. Thus, **technology aids scientific advances** which in turn can be used in **designing and making things for people to use**.
Energy is a quantitative property of a system that depends on the **motion** and interactions of **matter** and **radiation** within that system. That there is a single quantity called energy is due to the fact that a system's total energy is **conserved**, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in **motion**, **sound, light**, and **thermal energy**. "**Mechanical energy**" generally refers to some combination of motion and stored energy in an operating machine. "**Chemical energy**" generally is used to mean the energy that can be released or stored in chemical processes, and "**electrical energy**" may mean energy stored in a **battery** or energy transmitted by **electric currents**. Historically, different **units** and names were used for the energy present in these different phenomena, and it took some time before the relationships between them were recognized.
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and **transferred** between systems. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system.[4 (p. 126)] Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy. Fossil fuels, frequently used in power stations and generators, are a limited resource and their combustion contributes to global warming and climate change. Therefore, other ways of generating electricity have to be sought, whilst reducing demand and improving the efficiency of the processes in which we use it.
The **wavelength** and **frequency** of a wave are related to one another by the **speed** of travel of the wave, which depends on the type of wave and the **medium** through which it is passing. The **reflection, refraction, and transmission** of waves at an interface between two media can be modeled on the basis of these properties. Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Information

can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **Resonance** is a phenomenon in which waves add up in phase in a structure, growing in **amplitude** due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments.[4 (p. 132-133)] All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components of modern imaging, communications, and information technologies. (Boundary: Details of quantum physics are not formally taught at this grade level.)

Earth and Space Science

Earth and space science encompass processes that occur on Earth while also addressing Earth's place within our solar system and galaxy. At the high school level, students gain an understanding of these processes through a wide scale: unimaginably large to invisibly small.[1] *Earth and Space Sciences, more than any other discipline, are rooted in other scientific disciplines. Students, through the close study of earth and space, will find clear applications for their knowledge of gravitation, energy, magnetics, cycles, and biological processes. Educators should use the "connections" designations within these standards to assist students in making connections between scientific disciplines. Additionally, students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of causes, effects, and solutions for physical processes in the real world. The essential standards are those that every high school student is expected to know and understand. Plus standards in Earth and Space Science are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.*

Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. **Climate** is longer term and location sensitive; it is the range of a region's weather over 1 year or many years, and, because it depends on latitude and geography, it varies from place to place. The foundation for Earth's global climate system is the **electromagnetic radiation** from the sun as well as its **reflection, absorption, storage, and redistribution** among the **atmosphere, ocean, and land systems** and this energy's re-radiation into space. **Climate change** can occur when certain parts of Earth's systems are altered. **Geological evidence** indicates that past climate changes were either sudden changes caused by **alterations in the atmosphere**; **longer term changes** (e.g., ice ages) due to variations in solar output, Earth's orbit, or the orientation of its axis; or even **more gradual atmospheric changes** due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years. Earth's systems, being dynamic and interacting, cause **feedback effects** that can increase or decrease the original changes. A deep knowledge of how feedbacks work within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts. Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but **solid inner core**, a **liquid outer core**, a **solid mantle** and **crust**. The top part of the mantle, along with the crust, forms structures known as **tectonic plates**. Motions of the mantle and its plates occur primarily through **thermal convection**, which involves the **cycling of matter** due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior. The **geological record** shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

The **abundance of liquid water** on Earth's surface and its **unique combination of physical and chemical properties** are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.

Radioactive decay lifetimes and **isotopic content** in rocks provide a way of **dating** rock formations and thereby fixing the scale of **geological time**. Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old. **Tectonic processes** continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. Although active geological processes, such as plate tectonics and **erosion**, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. Beneath the Earth's solid crust is a hot layer called the mantle. The mantle is solid when under **pressure** but melts (and is called **magma**) when the pressure is reduced. In some places there are cracks (or thin regions) in the crust which can allow magma to come to the surface, for example in **volcanic eruptions**. The Earth's crust consists of a number of solid plates which move relative to each other, carried along by movements of the mantle. Where plates collide, mountain ranges are formed and there is a **fault line** along the **plate boundary** where earthquakes are likely to occur and there may also be volcanic activity. The Earth's surface changes slowly over time, with mountains being eroded by weather, and new ones produced when the crust is forced upwards.

Changes in the atmosphere due to **human activity** have increased **carbon dioxide** concentrations and thus affect climate. **Global climate models** are often used to understand the process of climate change because these changes are complex and can occur slowly over Earth's history. Though the magnitudes of humans' impacts are greater than they have ever been, so too are humans' abilities to model, predict, and manage current and future impacts. Materials important to modern technological societies are not uniformly distributed across the planet (e.g., oil in the Middle East, gold in California). Most elements exist in Earth's crust at concentrations too low to be extracted, but in some locations—where geological processes have concentrated them—**extraction** is economically viable. Historically, humans have populated regions that are climatically, hydrologically, and geologically advantageous for fresh water availability, food production via agriculture, commerce, and other aspects of civilization. **Resource availability** affects geopolitical relationships and can limit development. As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land for agriculture or drinkable water, are becoming scarcer and more valued. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical **costs and risks**, as well as **benefits**. New technologies and regulations can change the balance of these factors. Much energy production today comes from **nonrenewable sources**, such as coal and oil. However, advances in related science and technology are reducing the cost of energy from **renewable**

resources, such as sunlight. As a result, future energy supplies are likely to come from a much wider range of sources.
Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from **nuclear reactions** in their central cores. The Sun is one of millions of stars that together make up a galaxy called the Milky Way. Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars. **Nuclear fusion** within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a **supernova** stage and explode.
The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them. This system appears to have formed from a disk of dust and gas, drawn together by **gravity**. Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale **phenomena** observed on Earth. Planetary motions around the sun can be predicted **using Kepler's three empirical laws**, which can be explained based on **Newton's theory of gravity.** Kepler's laws describe common features of the motions of orbiting objects, including their **elliptical** paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (Boundary: application of laws rather than memorization should be emphasized.) Gravity holds Earth in orbit around the sun, and it holds the moon in **orbit** around Earth.
Our Sun is one of many stars that make up the **universe**, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores. The Sun is one of millions of stars that together make up a **galaxy** called the **Milky Way**. The next nearest star is much further away than the distance of the furthest planet, Neptune. The distances between and within galaxies are so great that they are measured in 'light years', the distance that light can travel in a year. There are billions of galaxies in the universe, almost unimaginably vast distances apart and perceived as moving rapidly away from each other. This apparent movement of galaxies indicates that the universe is expanding from an event called a 'big bang', about 13.7 billion years ago.

Life Science
Life science focuses on the patterns, processes, and relationships of living organisms. At the high school level, students apply concepts learned in earlier grades to real-world situations and investigations using the science and engineering practices to fully explore phenomena and to develop solutions to societal problems related to food, energy, health, and environment. The field of life science is rapidly advancing and new technology and information related to the study of life processes is being developed daily. Students in high school should have access to up-to-date information in the field while simultaneously gaining understanding of the historical developments which shaped today's understandings within the field. The standards for life science encompass the areas of cells and organisms; ecosystems, interactions, energy and dynamics; heredity; and biological diversity. Like earth and space sciences and physical sciences, "connections" with the life science standards allow educators to make connections across scientific disciplines. The essential standards are those that every high school student is expected to know and understand. Plus standards in life science are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

A complex set of **interactions** within an **ecosystem** can keep its numbers and types of **organisms** relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and **habitat** availability. Moreover, **anthropogenic changes** (induced by human activity) in the environment —including habitat destruction, **pollution**, introduction of **invasive species**, **overexploitation**, and **climate change** —can disrupt an ecosystem and threaten the survival of some **species.** Ecosystems have **carrying capacities**, which are **limits** to the numbers of organisms and populations they can support. These limits result from such **factors** as the availability of living and nonliving resources and from such challenges as **predation, competition**, and **disease**. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and **resources are finite**. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **Biodiversity** is increased by the formation of new species (**speciation**) and decreased by the loss of species (**extinction**). Biological extinction, being irreversible, is a critical factor in reducing the planet's natural capital. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having positive and negative impacts on biodiversity through **overpopulation**, **overexploitation**, **habitat destruction, pollution, introduction of invasive species, and climate change**. These problems have the potential to cause a major wave of biological extinctions—as many species or populations of a given species, unable to survive in changed environments, die out—and the effects may be harmful to humans and other living things. Thus sustaining biodiversity so that **ecosystem** functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. **Matter and energy are conserved** in each change. This is true of all biological systems, from individual cells to ecosystems. **Photosynthesis** and **cellular respiration** (including **anaerobic processes**) provide most of the energy for life processes. Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this **inefficiency**, there are generally fewer organisms at higher levels of a food web, and there is a **limit to the number of organisms that an ecosystem can sustain**. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil and are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved; some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. **Competition** among species is ultimately competition for the matter and energy needed for life.

Within cells there are many molecules of different kinds which interact in carrying out the functions of the cell. In multi-cellular organisms **cells communicate** with each other by passing substances to nearby cells to coordinate activity. A **membrane** around each cell plays an important part in **regulating what can enter or leave a cell**. Activity within different types of cells is regulated by **enzymes.** Systems of specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules, such as **water**, **proteins, carbohydrates, lipids,** and **nucleic acids**. Multi-cellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. **Feedback mechanisms** maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some **range**. Outside that range (e.g., at a too high or too low external temperature, with too little food or water available), the organism cannot survive. Feedback mechanisms can encourage (through **positive feedback**) or discourage (**negative feedback**) what is going on inside the living system.

The process of **photosynthesis** converts **light energy** to **stored chemical energy** by converting **carbon dioxide** plus **water** into **sugars** plus released **oxygen**. The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. For example, **aerobic** (in the presence of oxygen) **cellular respiration** is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. **Anaerobic** (without oxygen) cellular respiration follows a different and less efficient chemical pathway to provide energy in cells. Cellular respiration also releases the energy needed to **maintain body temperature** despite ongoing energy loss to the surrounding environment.

In multi-cellular organisms, individual cells grow and then divide via a process called **mitosis**, thereby allowing the organism to grow. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

Given a suitable medium, cells from a variety of organisms can be grown in situ, that is, outside the organism. These **cell cultures** are used by scientists to investigate cell functions and have medical implications such as the **production of vaccines, screening of drugs**, and **in vitro fertilization**. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Most cells are programmed for a limited number of cell divisions. Diseases, which may be caused by invading microorganisms, environmental conditions or defective cell programming, generally result in **disturbed cell function**. Organisms die if their cells are incapable of further division.

In **sexual reproduction**, a specialized type of cell division called **meiosis** occurs and results in the production of sex cells, such as **gametes** (**sperm and eggs**) or **spores**, which contain only one member from each **chromosome pair** in the parent cell.

The information passed from parents to offspring is coded in the **DNA** molecules that form the **chromosomes**. In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more **genetic variation**. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in **mutations**, which are also a source of genetic variation. **Environmental factors** can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect **expression of traits**, and hence affect the **probability** of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both **genetic and environmental factors.**

The overall sequence of genes of an organism is known as its **genome**. More is being learned all the time about genetic information by **mapping the genomes** of different kinds of organisms. When sequences of genes are known genetic material can be **artificially changed** to give organisms certain features. In **gene therapy** special techniques are used to deliver into human cells genes that are beginning to help in curing disease.

Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a **population** and (2) variation in the expression of that genetic information—that is, **trait variation**—that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be **reproduced** and thus are more common in the population.

Natural selection is the result of four factors: **(1)** the potential for a species to increase in number, **(2)** the **genetic variation** of individuals in a species due to **mutation** and **sexual reproduction**, **(3)** competition for an environment's limited supply of the **resources** that

individuals need in order to **survive** and **reproduce**, and **(4)** the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. **Natural selection** leads to **adaptation** —that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the **differential survival and reproduction** of organisms in a population that have an **advantageous heritable trait** leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can **change** when conditions change.
Changes in the **physical environment**, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the **extinction**—of some species. Species become extinct because they can no longer survive and reproduce in their **altered environment**. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' **evolution** is lost.