K-12 SCIENCE EDUCATION VISION

A K-12 Dublin City Schools science education engages *all students* in critical thinking and problem solving as they experience science and engineering. We believe that students can become scientifically literate citizens equipped with the knowledge and skills demanded by the ever-changing future, whether in the workforce or higher education.

We believe in developing our learners through high quality experiences that include:

- A challenging, collaborative and inquiry based environment.
- Opportunities to solve and investigate real-world problems that require critical and global thinking.
- Opportunities for students to build an identity as a scientist, able to interpret the natural world, participate productively in scientific practices and contribute to society in meaningful ways.
- Opportunities to research, generate and evaluate evidence and explanations that uphold or refute scientific data.

We believe these learning experiences will grow independent, confident students who will become creative, innovative adults that are capable of using informed scientific judgement to improve their world.

Instructional Agreements for Science Learning within the Dublin City Schools

1. Learning goals will be communicated to guide students through the expectations of science learning using a variety of instructional techniques and technology integration.
2. Teachers will ensure a safe, challenging learning environment focused on inquiry and science exploration.
3. Teachers will provide support to students as they learn to frame questions, assess and analyze data, and create and critique explanations – all important components of scientific and engineering practices.
4. Content standards will be learned in partnership with Ohio's Cognitive Demands for Science, Science and Engineering Practices and Nature of Science practices.

Nature of Science	
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Scientific Inquiry, Practice and Applications	All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.
Science is a Way of Knowing	Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
Science is a Human Endeavor	Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.
Scientific Knowledge is Open to Revision in Light of New Evidence	Science is not static. Science is constantly changing as we acquire more knowledge.

Scientific and Engineering Practices:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Ohio's Cognitive Demands for Science	
Cognitive Demand	**Description**
DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	Requires students to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information.
DEMONSTRATING SCIENCE KNOWLEDGE	Requires students to use scientific practices and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (Slightly altered from National Science Education Standards)
INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.
RECALLING ACCURATE SCIENCE	Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

GRADE 8

Grade 8 Course Goals:

Students in Grade 8 will focus on using scientific inquiry to discover patterns, trends, structures and relationships that may be inferred from simple principles. These principles are related to the properties or interactions within and between systems. Students will learn about physical earth, forces and motion, and species and reproduction.

Strand Connections:

Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.

PHYSICAL SCIENCE (PS)	
Topic: Forces and Motion This topic focuses on forces and motion within, on and around the Earth and within the universe.	
Content Statement	**Content Elaboration**
8.PS.1: Objects can experience a force due to an external field such as magnetic, electrostatic, or gravitational fields. Magnetic, electrical and gravitational forces can act at a distance.	This content statement involves a basic introduction to the field model. A field model can be used to explain how two objects can exert forces on each other without touching. Details about the field model are not required other than the idea that a field is a concept that is used to understand forces that act at a distance. An object is thought to have a region of influence, called a field, surrounding it. When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object. In grade 8, content will focus on connecting and organizing prior knowledge using the field model. Three types of fields should be investigated: gravitational, electric and magnetic. Every object with mass exerts a gravitational force on every other object with mass. These forces are hard to detect unless at least one of the objects is very massive (e.g., sun, planets). The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points toward the center of objects. Weight is the force that a mass experiences in a gravitational field. Weight is often confused with mass. Weight is proportional to mass, but depends upon the gravitational field at a particular location. An object will have the same mass when it is on the moon as it does on Earth. However, the weight (force of gravity) will be different at these two locations. Electrostatic fields exist around objects with a net charge. If a second object with a net

	charge is placed in the field, the two objects experience electric forces that can attract or repel them, depending on the sign of the charges involved. Magnetic fields exist around magnetic objects. If a second magnetic object is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the orientation of the objects involved. Magnetic field lines can be seen when iron filings are sprinkled around a magnet.Electricity is related to magnetism. In some circumstances, magnetic fields can produce electrical currents in conductors. Electric currents produce magnetic fields. Electromagnets are temporary magnets that lose their magnetism when the electric current is turned off. Building an electromagnet to investigate magnetic properties and fields can demonstrate this concept. Note 1: Magnetic poles are often confused with electric charges. It is important to emphasize the differences. Note 2: Mathematics is not used to describe fields at this level.
8.PS.2: Forces can act to change the motion of objects. The motion of an object is always measured with respect to a reference point. Forces can be added. The new force on an object is the sum of all of the forces acting on the object. If there is a nonzero net force acting on an object, its speed and/or direction will change. Kinetic friction and drag are forces that act in a direction opposite the relative motion of objects.	Motion can be described in different ways by different observers (e.g., a pencil held in someone's hand may appear to be at rest, but to an observer in a car speeding by, the pencil may appear to be moving). When multiple forces act on an object, their combined effort is what influences the object's motion (speed and direction). Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions. Such forces are said to be balanced. If all forces are balanced, the object will maintain its current motion (both speed and direction). This means if the object is stationary, it will remain stationary. If the object is moving, it will continue moving in the same direction and at the same speed. When the net force is nonzero, the forces are unbalanced and the object's motion will change. The forces acting on an object can be modeled by a force diagram. Forces are represented by arrows drawn on an isolated picture of the object. The direction of each arrow shows the direction of the force. The length of each arrow represents the magnitude of the force. The effect of the net force on the motion of an object can be predicted from a force diagram. The direction and relative size of the net force can be identified from force diagrams involving multiple forces. Diagrams with forces in both the horizontal and vertical directions can be considered. At this grade level, there should be unbalanced forces in only one of these dimensions. Forces can also act to change the direction of objects. If a force on an object acts toward a single center, the object's path may curve into an orbit around the center.Friction is a force that opposes sliding between two surfaces. For surfaces that are sliding relative to each other, the force on an object always points in the direction opposite the relative motion of the object. This force is known as kinetic friction. Drag is a force that opposes the motion of an object when a solid object moves through a fluid (e.g., gas, liquid). Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction

	of motion. A lack of understanding of friction can lead to the misconception that objects require a sustained force to continue moving. Experimentation with objects that have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address this misconception. In grade 8, friction will only be calculated from force diagrams. Static friction, as well as the equations for static and kinetic friction, are found in Physics.

EARTH AND SPACE SCIENCE (ESS)	
Topic: Physical Earth This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.	
Content Statement	**Content Elaboration**
8.ESS.1: The composition and properties of Earth's interior are identified by the behavior of seismic waves. The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth's interior. Earth has a core, a mantle, and a crust. Impacts during planetary formation generated heat. These impacts converted gravitational potential energy to heat. Earth's core is also able to generate its own thermal energy because of decaying atoms. This continuously releases thermal energy. Thermal energy generated from Earth's core drives convection currents in the asthenosphere. Note 1: Radioactive decay is not the focus; this will be discussed in Physical Science and Chemistry. Note 2: At this grade level, analyzing seismograms (e.g., amplitude and lag time) and reading a travel time curve are not the focus. At this grade the properties of seismic waves should be addressed.	It is important to provide background knowledge regarding how scientists know about the structure and composition of the interior of Earth (without being able to see it). Seismic data, graphics, charts, digital displays and cross sections can be used to study Earth's interior. Earth is differentiated into distinct chemical and physical layers. They correspond in the following way [the chemical layer is stated first, followed by the physical layers in parentheses]: the crust (upper lithosphere), the mantle (lower lithosphere, asthenosphere, mesosphere) and the core (outer and inner). The refraction and reflection of seismic waves, as they travel through the lithosphere to the inner core, is used to identify the different physical layers of Earth's interior. The thicknesses of each layer of Earth can vary and be transitional, depending on composition, density, temperature and pressure, rather than uniform and distinct as often depicted in textbooks. Earth and other planets in the solar system formed as heavier elements (primarily iron and nickel) coalesced in their centers and formed planetary cores. The less dense, lighter elements (potassium and sodium for example) remained closer to the planetary surface. This is planetary differentiation, a process through which distinct layers with characteristic chemical and/or physical properties are formed. A major period of planetary differentiation occurred in our solar system approximately 4.6 billion years ago (College Board Standards for College Success, 2009). There are three main sources of heat in Earth's interior: primordial heat left over from planetary accretion, the decay of radioactive elements and friction as materials move within the Earth. In addition to the composition of Earth's interior, the history of

	the formation of Earth and relationships among energy transfer, energy transformation and convection currents within the mantle and crust are essential in understanding sources of energy.
8.ESS.2: Earth's lithosphere consists of major and minor tectonic plates that move relative to each other. Historical data and observations such as fossil distribution, paleomagnetism, continental drift and seafloor spreading contributed to the theory of plate tectonics. The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle. Convection currents in the asthenosphere cause movements of the lithospheric plates. The energy that forms convection currents comes from deep within the Earth. There are three main types of plate boundaries: divergent, convergent and transform. Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountains or trenches) that are indicative of the type of boundary.	Historical data related to the modern-day theory of plate tectonics, which led to theories of continental drift (Wegener), convection theory (Holmes) and seafloor spreading (Hess, Deitz) is introduced. The data supporting these theories include paleontological data, paleoclimate data, paleomagnetic data and the continental "puzzle-like-fit" noticed as early as Magellan and by other mapmakers and explorers. Contemporary data is introduced, including seismic data, GPS/GIS data (documenting plate movement and rates of movement), robotic studies of the sea floor and further exploration of Earth's interior. Physical world maps, cross sections, models (virtual or 3D) and data are used to identify plate boundaries, movement at the boundary and the resulting feature or event. The relationship between heat from Earth's interior, convection in the magma and plate movement is explored. World distribution of tectonic activity of possible interest should be investigated (e.g., Ring of Fire, San Andreas Fault, Mid-Atlantic Ridge, Mariana Trench, Hawaiian Islands, New Madrid Fault System). Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys are included in the identification of plates and plate boundaries. Plate boundary identification (convergent, divergent, transform) is based on the resulting features or events. The focus is on the cause of plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names.
8.ESS.3: A combination of constructive and destructive geologic processes formed Earth's surface. Earth's surface is formed from a variety of different geologic processes, including but not limited to plate tectonics.	The interactions between the hydrosphere and lithosphere are studied as they relate to erosional events (e.g., flooding, mass movement). The characteristics of rocks and soil, climate, location, topography and geologic process are studied. Distinguishing between major geologic processes (e.g., tectonic activity, erosion, deposition) and the resulting feature on the surface of Earth is the focus of this content statement. It is important to build on what was included in the elementary grades (recognizing features), enabling students to describe conditions for formation. Topographic, physical and aerial maps, cross-sections, field trips and virtual settings are methods of demonstrating the structure and formation of each type of feature. Technology (e.g., remote sensing, satellite data, LANDSAT) can be used to access real-time photographs and graphics related to landforms and features. Factors that affect the patterns and features associated with streams and floodplains (e.g., discharge rates, gradients, velocity, erosion, deposition), glaciers (e.g., moraines, outwash, tills, erratics, kettles, eskers), tectonic activity (includes the features listed in the previous content statement),

	coastlines, flooding and deserts should be studied.
8.ESS.4: Evidence of the dynamic changes of Earth's surface through time is found in the geologic record. Earth is approximately 4.6 billion years old. Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism). There are different methods to determine relative and absolute age of some rock layers in the geologic record. Within a sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition). The geologic record can help identify past environmental and climate conditions.	Representations of the age of Earth should include a graphic demonstration of the immensity of geologic time, as this is a very difficult concept to grasp. The different methods used to determine the age of Earth are an important factor in this concept. In elementary grades, fossils are used to compare what once lived to what lives now, but the concept of Earth's age and the age of the fossils were not included (the concept of billions or millions of years was not age-appropriate). In grade 8, the concept of index fossils is a way to build toward understanding relative dating. Superposition, cross-cutting relationships and index fossils play an important role in determining relative age. Radiometric dating plays an important role in absolute age. The inclusion of new advances and studies is important in learning about the geologic record. Uniformitarianism can be an important key in understanding how scientists have interpreted the environmental conditions that existed throughout Earth's history. Fossil evidence also can indicate specific environments and climate conditions that help interpret the geologic record. Environmental and climate conditions can also be documented through the cryosphere as seen through ice cores. Relating Earth's climate history to present-day climate issues should include evidence from ice core sampling as well as evidence from the geologic record. Using actual data to generate geologic maps of local or statewide formations can connect to the real world. Field studies or geologic research (virtual/digital) can help identify local formations and interpret the environment that existed at the time they were formed. Analyzing and interpreting the data to draw conclusions about geologic history is an important part of this content statement.

LIFE SCIENCE (LS)	
Topic: Species and Reproduction This topic focuses on continuation of the species.	
Content Statement	**Content Elaboration**
8.LS.1: Diversity of species, a result of variation of traits, occurs through the process of evolution	The fossil record documents the variation in a species that may have resulted from changes in the environment. The fossil record is contained within the geologic record

and extinction over many generations. The fossil records provide evidence that changes have occurred in number and types of species. Fossils provide important evidence of how life and environmental conditions have changed. Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an organism or an entire species. Throughout Earth's history, extinction of a species has occurred when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment. Most species (approximately 99 percent) that have lived on Earth are now extinct. Note: Population genetics and the ability to use statistic mathematics to predict changes in a gene pool are reserved for high school Biology.	(ESS grade 8). Combining data from the geologic record and the fossil record, Earth's living history can be interpreted. Data and evidence from the fossil record can be used to further develop the concepts of extinction, biodiversity and the diversity of species. The term "transitional form" is used to describe intermediate organisms between ancestral forms and their descendants. Some examples of transitional forms were fossilized and found in the fossil record. Other transitional forms are missing from the fossil record. Evidence from the geologic and fossil record can be used to infer what the environment was like at the time of deposition. The variations that exist in organisms can accumulate over many generations, so organisms can be very different in appearance and behavior from their distant ancestors. Diversity can result from sexual reproduction. The sorting and combination of genes result in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other (this statement connects to the grade 8 Life Science content statement on reproduction and Mendelian Genetics). These variations may allow for survival of individuals when the environment changes. Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive and reproduce when conditions change. Note: Molecular clocks are not appropriate at this grade level
8.LS.2: Every organism alive today comes from a long line of ancestors who reproduced successfully every generation. Reproduction is the transfer of genetic information from one generation to the next. It can occur with mixing of genes from two individuals (sexual reproduction). It can occur with the transfer of genes from one individual to the next generation (asexual reproduction). The ability to reproduce defines living things.	Organisms reproduce either sexually or asexually. Some organisms are capable of both. In asexual reproduction, all genes come from a single parent, resulting in offspring genetically identical to their parent. Mitosis was introduced in grade 6. At this grade level, the end products of mitotic and meiotic cell divisions are compared as they relate to asexual and sexual reproduction. Mitosis and meiosis are addressed in preparation for the study of Mendelian genetics in 8.LS.3. In sexual reproduction, a single specialized cell from a female (egg) merges with a specialized cell from a male (sperm). Half of the nuclear genes come from each parent. The fertilized cell, carrying genetic information from each parent, multiplies forming the genetically complete organism. Each cell of an organism contains the same genetic information. As opposed to asexual reproduction, sexual reproduction results in offspring with new combinations of traits which may increase or decrease their chances for survival.
8.LS.3: The characteristics of an organism are a result of inherited traits received from parent(s). Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene. During	The traits of one or two parents are passed onto the next generation through reproduction. Traits are determined by instructions encoded in deoxyribonucleic acid (DNA), which forms genes. Genes have different forms called alleles. The principles of Mendelian genetics are introduced by reviewing Mendel's work. Mendel's two laws provide the theoretical base for future study of modern genetics. Mendel's first law, the Law of Segregation, and his second law, the Law of Independent Assortment, should

reproduction, genetic information (DNA) is transmitted between parent and offspring. In asexual reproduction, the lone parent contributes DNA to the offspring. In sexual reproduction, both parents contribute DNA to the offspring. Note 1: The focus should be the link between DNA and traits without being explicit about the mechanisms involved. Note 2: The ways in which bacteria reproduce is beyond the scope of this content statement. Note 3: The molecular structure of DNA is not appropriate at this grade level.	be demonstrated and illustrated in a variety of organisms. The concepts of dominant and recessive genes are appropriate at this grade level. Codominant traits such as roan color in horses and cows may be useful to provide further validation of the theory and to help dispel some misconceptions. Pedigree analysis is appropriate for this grade level when limited to dominant, recessive or codominance of one trait. The Law of Independent Assortment should only be explored in simple cases of dominant and recessive traits. Incomplete dominance is not suggested for this grade level to help avoid the misconception of “blending of traits.” Codominance is encouraged because both traits are expressed in the resulting offspring. Dihybrid crosses and sex-linked traits also are reserved for high school. A long-term investigation to analyze and compare characteristics passed on from parent to offspring through sexual and asexual reproduction can be conducted. These investigations can lead to questions about the phenotypes that appear in the resulting generations and what they infer about genotypes of the offspring.