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.

Dublin City Schools Science Graded Course of Study

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.

BIOLOGY

Biology Course Goals:

This course investigates the composition, diversity, complexity and interconnectedness of life on Earth. Fundamental concepts of heredity and evolution provide a framework through inquiry-based instruction to explore the living world, the physical environment and the interactions within and between them. Students engage in investigations to understand and explain the behavior of living things in a variety of scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

CELLS	
Building on knowledge from middle school (cell theory, cell division and differentiation), this topic focuses on the cell as a system itself (single-celled organism) and as part of larger systems (multicellular organism), sometimes as part of a multicellular organism, always as part of an ecosystem. The cell is a system that conducts a variety of functions associated with life. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration and biosynthesis of macromolecules are addressed at this grade level. The concept of the cell and its parts as a functioning biochemical system is more important than just memorizing the parts of the cell.	
Content Statement	**Content Elaboration**
B.C.1: Cell structure and function • Structure, function and interrelatedness of cell organelles • Eukaryotic cells and prokaryotic cells	● Characteristics of Life ● Discuss endosymbiotic theory & fossil evidence of the evolution of prokaryotic & eukaryotic cells ● Compare and contrast prokaryotic and eukaryotic cells; List examples of prokaryotic and eukaryotic cells. ● Describe the function of cellular structures. (Review structures/function but focus on <u>interrelatedness</u> of organelles) Nucleus — Cell Wall — Cilia Ribosomes — Golgi apparatus — Flagella Lysosome — Vacuole — Cytoskeleton Chloroplast — Mitochondria — ER – smooth & rough ● Distinguish between differences in cellular structures of plant cells vs animal cells ● Levels of biological organization within a multicellular organism; State that multicellular organisms have tissues and organs that are similar in function to cellular organelles (functions include regulation, homeostasis, cell cycle & transport.) ● Homeostasis ○ Maintaining a steady internal environment separate from the external environment (selective permeability of cell membrane & function of cell transport)

	● Feedback Loops ○ Compare negative and positive feedback mechanisms ○ Illustrate a model of negative or positive feedback including sensor, a control center, effectors and variables being regulated ● Draw and label a phospholipid. ● Define hydrophilic and hydrophobic and based on these properties describe why phospholipids form bilayers in water (draw and label a phospholipid bilayer) ● Describe the primary functions of the cell membrane. ● Define passive transport, diffusion, concentration gradient & dynamic equilibrium. ● Describe the process of diffusion.Predict how materials will diffusion across a selectively permeable membrane. ● Describe the process of facilitated diffusion. ● Define solute and solvent. ● Describe the process of osmosis, using the terms hypertonic, hypotonic and isotonic. ● Predict how water will move across a membrane based upon solute concentrations. ● Describe the process of active transport. ● Describe the process of bulk transport.
B.C.2: Cellular processes • Characteristics of life regulated by cellular processes • Photosynthesis, chemosynthesis, cellular respiration, biosynthesis of macromolecules	● State that the most frequently occurring elements in living things are C,H,N,O,P,S, which combine to form carbohydrates, lipids, proteins and nucleic acids. ● Include the role of water (dehydration synthesis & hydrolysis) & organic molecules (lipids, carbohydrates, nucleic acids & proteins). ● Focus on the biosynthesis of macromolecules, cellular reactions and the external conditions necessary for those reactions to take place ● List the characteristics of enzymes. Describe how enzymes work to catalyze chemical reactions (lower activation energy). ● Identify the structure and function of enzymes and substrates applying models such as lock and key or induced fit. ● Explain how environmental changes can affect enzyme function (include changes in temperature, pH & concentration) ● State that aerobic respiration occurs in mitochondria in eukaryotic cells. State the overall equation of aerobic respiration identifying the reactants and products ● Explain how energy is stored and released in molecules. ● Describe the aspects of chemical reactions (reactants, products, law of conservation of energy, not 100% efficient; include connection to cellular respiration & photosynthesis.) ● Describe the role of ATP in energy transformations. Draw and label the ATP cycle.

	• State that chlorophyll is the main photosynthetic pigment and that photosynthesis occurs within the chloroplasts of plants. Discuss role of accessory pigments in the process of photosynthesis. • State the overall equation of photosynthesis identifying the reactants and products. • Explain the connection between cellular respiration, photosynthesis and the carbon cycle. • Identify the cellular organelles involved in fermentation. Include inputs and outputs required for the process

HEREDITY, PROTEIN SYNTHESIS AND MUTATIONS	
Building on knowledge from elementary school (plants and animals have life cycles and offspring resemble their parents) and knowledge from middle school (reproduction, Mendelian genetics, inherited traits and diversity of species), Heredity focuses on the explanation of genetic patterns of inheritance. In middle school, students learn that living things are a result of one or two parents, and traits are passed to the next generation through either asexual or sexual reproduction. Foundational concepts of mitosis and meiosis are introduced in grades 6 and 8. In addition, they learned that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles.	
Content Statement	**Content Elaboration**
B.H.1: Cellular genetics	• Define the cell cycle. Describe cellular activities that happen during interphase. Describe why it is important for cells to replicate chromosomes before division. • Explain how the cytoplasm divides in animal and plant cells. (focus on the formation of the cleavage furrow in animals and the cell plate in plants) • Explain why it is important for cells to divide (maintain surface area to volume ratio, growth & development, repair, replace dead cells) In multicellular organisms the cells differentiate after division. • Explain how the cell cycle is regulated.Explain what can occur when the cell cycle is unregulated (include treatments for cancer)
B.H.2: Structure and function of DNA in cells	• Draw and label a replicated chromosome (include identification of sister chromatids and centromere). Explain when chromosomes are replicated and why it is important for cells to replicate chromosomes before division (include the correct number of chromosomes in human somatic cells) • Describe the double-helix structure of DNA. Draw and label a simple DNA molecule, including the identification of a nucleotide, nitrogenous bases, phosphates and deoxyribose sugars, position of hydrogen bonds.

	• Determine the missing nucleotide sequence of a strand if given the complementary nucleotide sequence. • Summarize the semiconservative process of DNA replication.Draw and label a diagram illustrating DNA replication (include the role of enzymes helicase and DNA polymerase) • Explain why the genetic code is 'universal' even though each species has its own unique genome. • State that the flow of genetic information is DNA-->RNA-->Protein (central dogma) • Define a gene. • Compare and contrast the structures and function of RNA and DNA. • State that gene expression is regulated. Genes have the ability to be turned 'on' and 'off' based on environmental cues (epigenetics). • State the purpose of transcription.Describe the process of transcription and its location. • State the purpose of translation.Describe the process of translation and its location. • Explain the relationship between structure and function of proteins. • Compare sexual and asexual reproduction (focus on genetic variation and number of parents). • Explain the importance of reducing chromosome number in sexual organisms through the process of meiosis (maintaining species specific chromosome number). • Define diploid, haploid and zygote. • Explain the major events that occur during Meiosis that lead to genetic variation. Compare the process and results of mitosis and meiosis. • Describe nondisjunction and explain how it can result in a monosomy or trisomy.
B.H.3: Genetic mechanisms and inheritance	• Describe Mendel's method of investigating inheritance. Discuss & connect Mendel's principles of dominance, segregation and independent assortment to meiosis. • Define genotype and phenotype. • Determine the possible offspring of a cross using a Punnett square (1 trait). • Predict the probability of two traits in offspring given parental genotypes (dihybrid) • Deduce the genotypes and phenotypes of individuals in pedigree charts. • Explain and predict the results of a cross involving incomplete dominanceInclude real world examples (i.e., snapdragon flower color). • Explain and predict the results of a cross involving codominance (focus on the ABO blood group in humans). • Explain and predict the results of a cross involving sex-linkage (Include red-green color-blindness and hemophilia). • Use real world examples to introduce gene interactions and their phenotypic effects [i.e. Polygenic (human skin color), epistasis (coat color in mammals), pleiotropy (sickle cell disease)]

	● Define linked genes. ● Dihybrid crosses can be used to explore linkage groups, gene interactions and phenotypic variations. Chromosome maps reveal linkage groups. ● Statistics and probability allow us to compare observations made in the real world with predicted outcomes. Given chi-squared (goodness of fit) test data, make an inference about the inheritance of a set of genes.
B.H.4: Mutations	● Define mutation and list possible causes. ● State where mutations must occur in order to pass them onto offspring. ● Classify mutations as gene mutations (e.g., insertion, deletion, substitution) or chromosomal mutations (e.g., trisomy, monosomy). ● Compare and contrast base pair substitution and frameshift mutations. (Example frameshift mutations include insertion and deletion mutations.) ● Evaluate chromosome maps to identify linkage groups.
B.H.5: Modern genetics	● The development of the model for DNA structure was the result of experimentation, hypothesis, testing, statistical analysis and technology as well as the studies and ideas of many scientists. James Watson and Francis Crick developed the current model based on the work of Rosalind Franklin and others.

EVOLUTION	
The basic concept of biological evolution is that Earth's present-day species descended from earlier, common ancestral species. At the elementary school level, evolution concepts include the relationship between organisms and the environment, interactions among parents and offspring and an introduction to the fossil record and extinction. At the middle school level, concepts include biodiversity (as part of biomes) and speciation, further exploration of the fossil record and Earth's history, changing environmental conditions (abiotic factors), natural selection and biological evolution. At the high school level, the study of evolution includes Modern Synthesis, the unification of genetics and evolution, historical perspectives of evolutionary theory, gene flow, mutation, speciation, natural selection, genetic drift and sexual selection.	
Content Statement	**Content Elaboration**
B.E.1: Mechanisms • Natural selection • Mutation • Genetic drift • Gene flow (immigration, emigration)	● Outline the historical development of evolutionary theory. ● Define population, gene pool and microevolution. ● Define evolution. ● Explain how natural selection leads to evolution. ● Describe mechanisms of speciation.

• Sexual selection	● List the 5 conditions that must be met to maintain Hardy-Weinberg equilibrium in a population. ● Use mathematical reasoning and Hardy-Weinberg's principle to explain deviations in observed gene frequencies compared to expected patterns based on the assumptions of the principle.
B.E.2: Speciation • Biological classification expanded to molecular evidence • Variation of organisms within a species due to population genetics and gene frequency	● Outline the evidence for evolution provided by the fossil record, biogeography, morphological comparisons and molecular comparisons. ● Using the evidence for evolution, construct cladograms and phylogenetic trees, incorporating recent molecular sequence data ● Explain how classification systems are used to illustrate evolutionary relationships.

BIODIVERSITY, ECOSYSTEMS, LOSS OF DIVERSITY	
Building on knowledge from elementary school (interactions of organisms within their environment and the law of conservation of matter and energy, food webs) and from middle school (flow of energy through organisms, biomes and biogeochemical cycles), this topic at the high school level focuses on the study of diversity and similarity at the molecular level of organisms. Additionally, the effects of physical/chemical constraints on all biological relationships and systems are investigated. The unidirectional flow of energy and the cycling of matter as organisms grow, reproduce and die occurs at all levels of biological organization. Previous knowledge focused on biological systems at equilibrium; at the high school level, biological systems not at equilibrium and their responses are considered. Diagrams and models are used to explain the effects of real-world interactions and events within an ecosystem.	
Content Statement	**Content Elaboration**
B.DI.1: Biodiversity • Genetic diversity • Species diversity	● Use mathematical reasoning to interpret exponential or logistic growth models. ○ Outline how population size is affected by natality, mortality, immigration and emigration. Technology must be used to access real-time/authentic data. ● Compare and contrast exponential growth and logistic growth. ○ Include analysis of graphs (s- and j-curves) and the impact of limiting factors (i.e., competition) that establish a carrying capacity of an environment. ● Recognize the variables involved in exponential & logistic growth. ● Explain why cyclic fluctuations exist in populations.
B.DI.2: Ecosystems • Equilibrium and disequilibrium • Carrying capacity	● Define ecosystem and explain why there are different types found in the biosphere. ● Explain how organisms transform energy and matter as they survive and reproduce. ● Explain the impact of energy's unidirectional flow.

B.DI.3: Loss of diversity • Climate change • Anthropocene effects • Extinction • Invasive species	● Predict how food chains/webs would be impacted by introducing a potentially hazardous substance. ● Predict the effect of geological, biological, and environmental changes on a population within an ecosystem