DUBLIN
CITY SCHOOLS

K-12 SCIENCE
Graded Course of Study
2025

A K-12 Dublin City Schools science education aims to create lifelong learners who are curious, critical thinkers, and effective collaborators, equipped with the scientific knowledge and skills necessary to navigate and shape a complex and ever-changing world.

Our vision is to inspire students to develop a deep appreciation for science and its applications, empowering them to:

- Ask questions, seek answers, and explore the natural world with a sense of wonder and curiosity.
- Think critically and creatively to solve problems and make informed decisions as a scientifically literate citizen.
- Communicate and collaborate effectively in our diverse community and beyond to address common challenges and create innovative solutions.
- Build their own identity as a scientist in order to apply scientific concepts and methods to understand and address real-world issues competently and confidently.
- Develop the resilience, adaptability, and perseverance needed to succeed in a rapidly evolving world.

Instructional Agreements for Science Learning within the Dublin City Schools

- Teachers will provide opportunities for students to engage in hands-on experiences, projects, and real-world simulations to provide context and relevance to science concepts.
- Teachers will create an environment that emphasizes the importance of effort, perseverance, and reflection in order to learn and grow from both success and failure.
- Content standards will be learned in conjunction with best practices regarding science education.

Together, we will cultivate resourceful, adaptable, and collaborative individuals with the ability to tackle real-world challenges with resilience and innovation.

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	
Educators will refer to "Ohio's Cognitive Demands for Science" to create experiences for students to engage in science content and demonstrate understanding of scientific concepts in ways that align with current research about how people learn.	
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

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	
This topic focuses on the cell as a system itself (single-celled organism) and as part of larger systems, 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	Cellular Structure • Describe the function of cellular structures. (Review structures/function but *focus* on interrelatedness 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.) Eukaryotic cells and prokaryotic cells • Discuss endosymbiotic theory & evidence of the evolution of prokaryotic & eukaryotic cells. • Compare and contrast prokaryotic and eukaryotic cells. • List examples of prokaryotic and eukaryotic cells.

	Cell membranes ● Describe the primary functions of the cell membrane. ● Define solute and solvent. ● 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). Passive and active transport ● 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. ● Describe the process of active transport. ● Describe the process of bulk transport. ● Describe the process of osmosis, using the terms hypertonic, hypotonic and isotonic. ● Predict how water will move across a membrane based upon solute concentrations. ● Homeostasis ○ Maintaining a steady internal environment separate from the external environment (selective permeability of cell membrane & function of cell transport).
B.C.2: Cellular processes	Characteristics of life regulated by cellular process ● 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. Photosynthesis, chemosynthesis, cellular respiration, biosynthesis and macromolecules ● State that chlorophyll is the main photosynthetic pigment and that photosynthesis occurs within the chloroplasts of plants. ● 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.
	• 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.
	• 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.
	
	Enzymes
	• 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)

HEREDITY, PROTEIN SYNTHESIS AND MUTATIONS	
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. 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	• Explain how the genome directs protein production and how gene expression influences cell specialization and reproduction. • Define the cell cycle and 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	Chromosomes and Cell Division • 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). DNA Structure and Replication • 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). Gene Expression and Protein Synthesis • 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). • Compare and contrast the structures and function of RNA and DNA. • Define a gene and understand that gene expression is regulated (the ability to be turned 'on' and 'off' based on environmental cues (epigenetics))…….. • State the purpose of transcription, describing the process of and its location. • State the purpose of translation, describing the process and its location. • Explain the relationship between structure and function of proteins. Reproduction • Compare sexual and asexual reproduction (focus on genetic variation and number of parents).

	• Explain the major events that occur during meiosis that lead to genetic variation. Compare the process and results of mitosis and meiosis. • 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. • Describe nondisjunction and explain how it can result in a monosomy or trisomy.
B.H.3: Genetic mechanisms and inheritance	Mendelian Genetics • 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. Beyond Mendelian Genetics • Explain and predict the results of a cross involving incomplete dominance. Include 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 and recognize them on chromosome maps. • Dihybrid crosses can be used to explore linkage groups, gene interactions and phenotypic variations. Chromosome maps reveal linkage groups. Statistical Analysis • Statistics and probability allow us to compare observations made in the real world with predicted outcomes.
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.)
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 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	Outline the historical development of evolutionary theory. • Define population, gene pool and microevolution • Define evolution Describe mechanisms of speciation. • Natural selection • Mutation • Genetic drift • Gene flow (immigration, emigration) • Sexual selection Equilibrium in a population • List the 5 conditions that must be met to maintain Hardy-Weinberg equilibrium in a population. • Use 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 • 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	
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	Populations of individual species and groups of species comprise a vast reserve of genetic diversity. • Explain the role of genetic diversity in a species' survival.

B.DI.2: Ecosystems	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.
	
	Population trends
	• Use mathematical reasoning to interpret exponential or logistic growth models.
	  ○ Outline how population size is affected by natality, mortality, immigration and emigration.
	• 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.3: Loss of diversity	• Predict the effect of geological, biological, and environmental changes on a population within an ecosystem.
	  ○ Climate change
	  ○ Anthropocene effects

	○ Extinction ○ Invasive species ● Predict how food chains/webs would be impacted by introducing a potentially hazardous substance.