Science Georgia Standards of Excellence

SCIENCE - Microbiology

The Science Georgia Standards of Excellence are designed to provide foundational knowledge and skills for all students to develop proficiency in science. The Project 2061's *Benchmarks for Science Literacy* and the follow up work, *A Framework for K-12 Science Education* were used as the core of the standards to determine appropriate content and process skills for students. The Science Georgia Standards of Excellence focus on a limited number of core disciplinary ideas and crosscutting concepts which build from Kindergarten to high school. The standards are written with the core knowledge to be mastered integrated with the science and engineering practices needed to engage in scientific inquiry and engineering design. Crosscutting concepts are used to make connections across different science disciplines.

The Science Georgia Standards of Excellence drive instruction. Hands-on, student-centered, and inquiry-based approaches should be the emphasis of instruction. The standards are a required minimum set of expectations that show proficiency in science. However, instruction can extend beyond these minimum expectations to meet student needs.

Science consists of a way of thinking and investigating, as well a growing body of knowledge about the natural world. To become literate in science, students need to possess sufficient understanding of fundamental science content knowledge, the ability to engage in the science and engineering practices, and to use scientific and technological information correctly. Technology should be infused into the curriculum and the safety of the student should always be foremost in instruction.

The microbiology course is designed to continue student investigations that began in grades K-8 and high school biology and chemistry. This curriculum is extensively performance and laboratory based. It integrates the study of microbial physiology, ecology, and genetics with instruction focusing on the impact microorganisms have on health, agriculture, biotechnology and the environment. Careers related to medicine, healthcare, research, food science and biotechnology should be emphasized throughout the course. Real-life applications should be emphasized through case studies concerning diseases; epidemiology; food preparation and safety; and use of microbes in industry, agriculture, biotechnology and the environment.

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SMI1. Obtain, evaluate, and communicate information regarding the historical progression of the core ideas of microbiology.

a. Obtain, evaluate, and communicate information relating the importance of microscopy to the origins of microbiology.
b. Ask questions to obtain information regarding the use of Koch's postulates to identify pathogens and other microorganisms.
(*Clarification statement*: Address the premise of Koch's work and include why Koch's Postulates do not apply to all pathogens.)
c. Construct explanations to illustrate how advances in technological developments have driven major innovations in microbiology (e.g. biotechnology, microbial ecology, medical microbiology, etc.)

SMI2. Obtain, evaluate, and communicate information to differentiate among types of microorganisms based on defining characteristics.

a. Develop and use models to distinguish between different kinds of microorganisms (Prokaryotes and Eukaryotes) based on cellular structure (including but not limited to, cell wall, cell membrane, organelles, cilia, and flagella), molecular biology (plasmids, DNA, RNA and proteins), and biochemical composition (lipids, proteins, and carbohydrates).
b. Construct explanations of how viruses differ from other cellular parasites.
c. Construct explanations for the relative sizes and different types of cell shapes of microorganisms.
d. Plan and carry out investigations to explore various methods used to visualize microorganisms.

SMI3. Obtain, evaluate, and communicate information to examine the structural components of prokaryotic and eukaryotic microorganisms and their functions.

a. Use models to investigate and compare structural properties of prokaryotic and eukaryotic membranes and the functions associated with these membranes.
b. Construct an argument based on evidence on how prokaryotic cell walls differ from eukaryotic cell walls, and how these differences contribute to their function.
c. Develop and use models to demonstrate how internal organization differs between prokaryotes and eukaryotes and explain the functions of internal structures.
d. Construct an explanation of the endosymbiotic theory and its evolutionary relevance.

SMI4. Obtain, evaluate, and communicate information on how microorganisms generate energy for cellular functions.

a. Construct an explanation of how microorganisms use photosynthesis, cellular respiration, and/or chemosynthesis to generate energy as ATP to drive cell function.

SMI5. Obtain, evaluate, and communicate information regarding the molecular mechanisms underlying DNA replication, gene expression (transcription and translation), and genetic variation, in microbes.

a. Develop and use models to investigate and compare the molecular mechanisms involved in DNA replication in prokaryotes and eukaryotes.
b. Develop and use models to demonstrate the molecular basis of gene expression (transcription) in microbes.
c. Construct explanations on how genetic variations in microbes arise due to mutations and gene transfer (via transformation, transduction, and/or conjugation) and how these genetic variations affect survival and functioning of prokaryotes.
d. Obtain, evaluate, and communicate information to compare and contrast sexual and asexual reproduction of eukaryotes, asexual reproduction of prokaryotes, and replication of viruses.
e. Construct an explanation of how genetic variation can lead to microbial evolution and ultimately how this information impacts modern biotechnological applications.

SMI6. Obtain, evaluate, and communicate information to determine parameters affecting prokaryotic microbial growth, ways of controlling microbial growth and how microorganisms respond to control mechanisms.

a. Use mathematics and computational thinking to predict and model the growth phases of microbial populations and the factors that influence these phases.
b. Construct an argument based on evidence on how nutritional requirements and environmental factors can influence microbial growth.
c. Analyze and interpret data to compare various physical and chemical methods used to control microbial growth.
   (*Clarification statement:* "Control" should include increasing, decreasing, and/or preventing the growth of microorganisms.)
d. Construct an argument using multiple forms of evidence regarding the modes of actions of antimicrobials (antibiotics, antifungals, and other pharmaceuticals) in preventing the growth of microorganisms.
e. Ask questions and define problems related to how the use of antimicrobials influences the evolution of resistant pathogens via genetic changes in the population (e.g., the evolution of multi-drug resistant bacteria, treatment resistant HIV, or viral recombination).

SMI7. Obtain, evaluate, and communicate information to analyze the impact of microorganisms in the environment and their uses in biotechnology, agriculture, and industry.

a. Construct an explanation for the prevalence and diversity of microorganisms in various environments.
b. Ask questions to investigate the roles of microorganisms in global nutrient cycling and primary production in soil, fresh water, and marine ecosystems.
c. Analyze and interpret data to determine the impact of microorganisms on water and soil quality.
d. Construct an argument from evidence to justify the use of microorganisms in industry, agriculture, and biotechnology.
    - Relate the use of microbes to their rapid growth, ease of genetic manipulation, and accessibility.
    - Consider bioethical implications of using genetically modified organisms (GMOs) in biotechnology.

SMI8. Obtain, evaluate, and communicate information to examine relationships among microbes and other organisms.

a. Construct an argument to support the variety of relationships (symbiotic and pathogenic) between humans and microbes.
b. Construct an argument to support the mutualistic relationship between microbes and other organisms (plants, animals & fungi).
c. Ask questions to gather and communicate information about how pathogenic microbes cause disease in humans and other organisms.
d. Obtain, evaluate, and communicate information to demonstrate how higher organisms defend against pathogenic microbes.