**Roanoke Valley Governor’s School for Science and Technology
RVGS Biology
Competency List**

(Last updated: May, 2022)

RVGS Biology is an in-depth, accelerated course that emphasizes an inquiry-based approach to the study of living organisms. This course is equivalent to an introductory college course for science majors. The major themes include evolution and the unity and diversity of life; principles of cell and molecular biology with an emphasis on DNA technology; Mendelian genetics; ecology; and energy flow in the cell, organism, and ecosystem. Virginia biology standards of learning are covered during the course. (Dual enrollment course with Virginia Western Com-munity College) This course is taught using best practices in gifted education. Each competency is aligned with Hockett’s five principles of gifted education:

**Gifted Education Principles:**( Hockett, J.A. (2009) “Curriculum for Highly Able Learners That Conforms to General Education and Gifted Education Quality Indicators.” *Journal of Education for the Gifted***. Vol. 32, No. 3, p. 394-440)**

1. High-quality curriculum for gifted learners uses a conceptual approach to organize or explore content that is discipline based and integrative.
2. High-quality curriculum for gifted learners pursues advanced levels of understanding beyond the general education curriculum through abstraction, depth, breadth, and complexity.
3. High-quality curriculum for gifted learners asks students to use processes and materials that approximate those of an expert, disciplinarian, or practicing professional.
4. High-quality curriculum for gifted learners emphasizes problems, products, and performances that are true to life, and outcomes that are transformational.
5. High-quality curriculum for gifted learners is flexible enough to accommodate self-directed learning fueled by student interests, adjustments for pacing, and variety.

When enabling objectives correspond to 2018 Virginia Standards of Learning and VWCC Biology 101 and 102 Course Outcomes (CO), they are cross-referenced in the second column of the table.

COMPETENCY I (VCCS Core Competency 1, National Science Education Standards on Inquiry-Based Learning, and Science Practices for AP Biology)

**Conduct individual and group scientific investigations using the scientific method.**

*Enabling Objectives:*

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| 1. Engage in scientific questioning by posing questions, refining questions, and evaluating questions.
 | SOL BIO.1a |
| 1. Create hypotheses. Design and carry out individual and group investigations that test these hypotheses.
 | SOL BIO.1a |
| 1. Design testable investigations to solve problems that evolve from previous investigations.
 | SOL BIO.1b |
| 1. Organize data and observations from lab and field settings into appropriate forms for analysis.
 | SOL BIO.1c |
| 1. Analyze and interpret experimental results in terms of accepting or rejecting hypotheses.
 | SOL BIO.1c |
| 1. Analyze data and create reasonable conclusions from observations and experimental results.
 | SOL BIO.1d |
| 1. Evaluate accuracy, confidence, and sources of experimental error based on number of trials and variance in the data.
 | SOL BIO.1d |
| 1. Identify and analyze sources of error inherent in experimental designs. Recognize, evaluate, and discuss contradictory or unusual data
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| 1. Apply mathematics, graphing, and statistics to laboratory and research situations.
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| 1. Use appropriate software for data analysis.
 | SOL BIO.1b |
| 1. Make use of computer-interfaced probes and sensors for data collection and analysis.
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| 1. Use tools of biotechnology including micropipettes, electrophoresis chambers, thermal cyclers, and bioinformatics tools online.
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| 1. Select and utilize appropriate textbooks, journal articles, and web information resources for specific research situations.
 | SOL BIO.1f |
| 1. Use representations and models to communicate scientific phenomena and solve scientific problems.
 | SOL BIO.1cSOL BIO.1e |

COMPETENCY II

**Understand and investigate the chemical and biochemical molecules essential for life.**

*Enabling Objectives:*

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| 1. Investigate the chemistry of water.
 | Exceeds standards. |
| 1. Relate hydrogen ions to the pH scale, and discuss the importance of buffers in biological systems
 | Exceeds standards. |
| 1. Relate the properties of water to the existence of life on earth.
 | SOL BIO.2aBio 101 CO2 |
| 1. Apply properties of water to movement of water through the plant.
 | Bio 101 CO12 |
| 1. Relate the properties of the carbon atom to the existence of life on earth.
 | Exceeds standards. |
| 1. Identify the common functional groups found in organic molecules and predict the properties of a molecule based on the functional groups present.
 | Exceeds standards. |
| 1. Apply the chemical processes of hydrolysis and dehydration synthesis to the break-down and creation of macromolecules.
 | Exceeds standards. |
| 1. Recognize examples (verbal and structural) and major functions of the 4 groups of macromolecules.
 | SOL BIO.2bBio 101 CO2 |
| 1. Evaluate the importance of the relationship of structure to function with respect to the four major groups of macromolecules.
 | Exceeds standards. |
| 1. Draw an amino acid and identify a peptide bond in a polypeptide chain.
 | Exceeds standards. |
| 1. Describe the levels of protein structure and discuss reasons for protein denaturation.
 | Bio 101 CO2 |
| 1. Use CN3D to analyze the structure of a protein.
 | Exceeds standards. |

COMPETENCY III

**Investigate and understand the relationship between cell structure and function.**

*Enabling Objectives:*

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| 1. Evaluate the cell theory in light of historical technological advances.
 | SOL BIO.3a |
| 1. Compare and contrast a prokaryotic and eukaryotic cell.
 | Bio 101 CO3 |
| 1. Discuss reasons why cells are generally small. Apply understanding of surface area to volume ratio to specific cellular and physiological processes.
 | Bio 102 CO2 |
| 1. Relate the structure of parts and organelles of the cell to their functions.
 | SOL BIO.3bBio 101 CO3 |
| 1. Cite evidence to support the endosymbiont theory of the evolution of chloroplasts and mitochondria.
 | Exceeds standards. |
| 1. Relate the structure of the cell membrane to cell function.
 | Exceeds standards. |
| 1. Predict whether or not an ion or molecule would diffuse through the cell membrane based on the ion or molecule’s chemical and physical properties and then experimentally demonstrate whether the ion or molecule does pass through a membrane model.
 | Exceeds standards. |
| 1. Contrast passive and active transport.
 | SOL BIO.3d |
| 1. Describe the importance of cell surface proteins in cell communication, cell recognition, and pathogen entry into the cell.
 | SOL BIO.4a-e |
| 1. Understand the three stages of cell signaling via a G protein coupled receptor. Describe a signaling pathway of interest in detail.
 | Exceeds standards. |
| 1. Observe cells and capture images using a digital light microscope. Relate observations to cell structure and function. Incorporate and annotate images for lab reports.
 | Exceeds standards. |

COMPETENCY IV

**Analyze the importance of energy to the cell, organism, and ecosystem.**

*Enabling Objectives:*

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| 1. Relate the laws of thermodynamics to cells, organisms, and ecosystems.
 | Exceeds standards. |
| 1. Use free-energy change to predict if a reaction is spontaneous or non-spontaneous.
 | Exceeds standards. |
| 1. Describe how ATP powers cellular work.
 | Exceeds standards. |
| 1. Describe how enzymes work and discuss the importance of enzyme regulation to homeostasis and metabolism.
 | BIO.2c |
| 1. Experimentally determine the rate of reaction and design an experiment involving some aspect of enzyme activity.
 | SOL BIO.1a-fContent exceeds standards. |
| 1. Describe the importance of enzyme regulation and its role in an example of interest.
 | Exceeds standards. |
| 1. Analyze the flow of energy from the sun to molecules in photosynthesis, including details of the light reactions and Calvin cycle.
 | SOL BIO.2eBio 101 CO4 |
| 1. Discuss the movement of carbon, nitrogen, and phosphorus within and between organisms and relate each element to an organic molecule of importance to cells.
 | SOL BIO.8b |
| 1. Discuss the photosynthesis-transpiration compromise.
 | Bio 101 CO4 |
| 1. Analyze the flow of energy from food molecules to ATP, including details of glycolysis, the citric acid cycle, and oxidative phosphorylation.
 | SOL BIO.2eBio 101 CO4 |
| 1. Generate a question about photosynthesis and/or cellular respiration and gather data to answer it.
 | SOL BIO.1a-fContent exceeds standards. |
| 1. Evaluate the importance of membranes to harvesting energy in the cell.
 | Exceeds standards. |
| 1. Describe anaerobic respiration, including anaerobic electron transport.
 | Exceeds standards. |
| 1. Discuss predation as a means of moving nutrients and energy through ecosystems.
 | SOL BIO.8b |
| 1. Experimentally determine primary productivity. Discuss the importance of primary production to an ecosystem.
 | SOL BIO.1a-f |
| 1. Evaluate a trophic pyramid and relate the one-way flow of energy through ecosystems to the laws of thermodynamics.
 | SOL BIO.8bBio 102 CO4 |
| 1. Relate the cycling of nutrients through ecosystems to predation and decomposition.
 | SOL BIO.8d |
| 1. Evaluate the costs and benefits of the use of inputs such as fertilizers to the ecosystem.
 | Exceeds standards. |
| 1. Discuss advantages and disadvantages of different plant and animal reproductive strategies in relation to finite energy availability.
 | Exceeds standards. |

COMPETENCY V

**Investigate and understand mechanisms and patterns of inheritance.**

*Enabling Objectives:*

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| 1. Demonstrate how the process of mitosis results in two identical daughter cells.
 | SOL BIO.3cBio 101 CO5 |
| 1. Describe factors that regulate the cell cycle.
 | Exceeds standards. |
| 1. Describe how failure to maintain homeostasis with respect to the cell cycle leads to cancer.
 | Exceeds standards. |
| 1. Demonstrate how the process of meiosis leads to four haploid cells, genetically distinct from the parent cell.
 | SOL BIO.5dBio 101 CO5 |
| 1. Discuss the importance of independent assortment of chromosomes, crossing over, and random fertilization to the generation of variation among offspring and evolution.
 | SOL BIO.7b |
| 1. Compare and contrast the advantages and disadvantages of sexual and asexual reproduction.
 | SOL BIO.7b |
| 1. Relate movement of chromosomes during meiosis to Mendel’s laws of inheritance.
 | Bio 101 CO6 |
| 1. Use Mendel’s laws of inheritance to predict genotypes and phenotypes in monohybrid, dihybrid, and sex-linked crosses.
 | SOL BIO.5cBio 101 CO6 |
| 1. Discuss limitations of Mendel’s views on inheritance and recognize the importance of the environment, epigenetics, and multiple gene interactions in the production of complex traits such as intelligence.
 | Exceeds standards. |
| 1. Experimentally determine the mechanisms of inheritance in a model organism such as Drosophila, zebra fish, or Brassica.
 | Exceeds standards. |
| 1. Describe how chromosomal defects cause disorders in humans.
 | Exceeds standards. |
| 1. Describe the reproductive systems of the human male and female.
 | Bio 102 CO2 |

COMPETENCY VI

**Describe the cellular processes and evaluate the applications and bioethics surrounding the field of molecular biology**.

*Enabling Objectives:*

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| 1. Describe the structure and replicative cycle of a virus.
 | SOL BIO.4a |
| 1. Describe experiments that led to the understanding of DNA as the molecule of inheritance and the structure of the DNA molecule.
 | SOL BIO.5bBio 101 CO8 |
| 1. Describe the process of DNA replication.
 | SOL BIO.3cExceeds standards |
| 1. Relate the structure of DNA to its function of replication and director of protein synthesis.
 | SOL BIO.2dSOL BIO.5aBio 101 CO9Exceeds standards |
| 1. Compare and contrast the processes of gene expression in eukaryotic and prokaryotic cells.
 | Exceeds standards. |
| 1. Describe an example of how bacteria respond to their environment through regulation of gene expression.
 | Exceeds standards. |
| 1. Describe the role of differential gene expression in a multicellular organism.
 | Exceeds standards. |
| 1. Describe the process of cloning.
 | Exceeds standards. |
| 1. Identify the points at which eukaryotic gene expression may be regulated and give an example of each.
 | Exceeds standards. |
| 1. Describe the role that microRNAs play in gene expression.
 | Exceeds standards. |
| 1. Describe tools used in DNA technology such as restriction enzymes and CRISPR/Cas9 and their current and potential applications.
 | SOL BIO.5e |
| 1. Use a traditional polymerase chain reaction and gel electrophoresis to answer a question in an experiment.
 | Exceeds standards. |
| 1. Experimentally transform bacterial with plasmids.
 | Exceeds standards. |
| 1. Use bioinformatics resources online (including BLAST) to analyze genes and answer questions.
 | Exceeds standards. |
| 1. Evaluate ethical issues surrounding DNA technology and propose solutions.
 | SOL BIO.5e |

COMPETENCY VII

**Investigate ways in which populations evolve and relate the process of evolution to the unity and diversity of life.**

*Enabling Objectives:*

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| 1. Evaluate pre-Darwinian ideas about the evolution of living things.
 | Exceeds standards. |
| 1. Summarize and defend evidence for the evolution of living things.
 | SOL BIO.7aSOL BIO.7dBio 102 CO5 |
| 1. Analyze the theory of natural selection and apply the process to societal issues such as antibiotic resistance in bacteria and pesticide resistance in mosquitoes.
 | SOL BIO.7cBio 102 CO5 |
| 1. Discuss the phenomenon of sexual selection and provide evidence that it acts on populations.
 | Exceeds standards. |
| 1. Describe causes of microevolution.
 | Bio 102 CO5 |
| 1. Describe co-evolution and discuss adaptations species have in response to each other.
 | Exceeds standards. |
| 1. Use the Hardy-Weinberg equation to determine allele frequency in a population.
 | Exceeds standards. |
| 1. Use understanding of the genomic events such as duplication, rearrangement, and mutation of DNA to explain mechanisms of macroevolution in terms of pattern formation and other developmental genes.
 | Exceeds standards. |
| 1. Discuss mechanisms and rates of speciation.
 | Bio 102 CO5 |
| 1. Describe key events in life’s history.
 | Exceeds standards. |
| 1. Describe how our understanding of classification has changed as scientists understand more about evolutionary histories.
 | SOL BIO.6dSOL BIO.6f |
| 1. Construct a phylogenetic tree using given shared characteristics.
 | Exceeds standards. |

COMPETENCY VIII

**Investigate and understand dynamic equilibria within populations, communities, and ecosystems.**

*Enabling Objectives:*

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| 1. Summarize the factors that affect population density, distribution and dynamics.
 | SOL BIO.8 a |
| 1. Evaluate the idea of carrying capacity.
 | SOL BIO.8 aBio 102 CO3 |
| 1. Distinguish between niche and habitat.
 | Bio 102 CO3 |
| 1. Analyze intraspecific and interspecific population interactions.
 | SOL BIO.8 aBio 102 CO3 |
| 1. Discuss how communities are affected by interspecific interactions, disturbances, biogeographical factors, and pathogens.
 | SOL BIO.8 cSOL BIO.8dBio 102 CO3 |
| 1. Evaluate the impact of human behavior on the major biogeochemical cycles. Propose solutions to current problems.
 | SOL BIO.8bSOL BIO.8dBio 102 CO4 |
| 1. Evaluate the impact of human behavior on different levels of biodiversity in the ecosystem. Propose solutions to current problems.
 | SOL BIO.8d |

COMPETENCY IX

**Apply understanding of energy, homeostasis, regulation, and evolution to life functions of archaea, eubacteria, and eukarya form and function.**

*Enabling Objectives:*

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| 1. Describe the diversity of prokaryotes.
 | Bio 101 CO10 |
| 1. Discuss 4 major events in the evolution of plants.
 | Bio 101 CO11 |
| 1. Relate angiosperm success to their unique life cycle.
 | Bio 101 CO12 |
| 1. Discuss the evolution of complexity in animals.
 | Bio 102 CO1Bio 102 CO2 |
| 1. Provide examples and discuss the importance of how negative feedback loops are used in the cell, a plant, or an animal.
 | Bio 102 CO2 |
| 1. Provide examples and discuss the importance of how positive feedback loops are used in the cell, a plant, or an animal.
 | Bio 102 CO2 |
| 1. Discuss mechanisms for obtaining nutrients and eliminating wastes in the cell, a plant, or an animal.
 | Bio 102 CO2 |
| 1. Describe the human immune system including both non-specific and specific immune responses.
 | Bio 102 CO2 |
| 1. Describe the historical development and understanding of the causative agents of disease.
 | SOL BIO.4e |