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

(Last updated: August 16, 2023)

This course is designed to introduce students to the wide array of tools and applications in the area of biotechnology while allowing them to complete an experimental research project in a specific area of interest. The major themes in the course include DNA technology, the use of proteins and living organisms as tools in biotechnology, the ways in which biotechnology can be used to improve the quality of human life, and the ethical issues surrounding all of these areas.

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.

COMPETENCY I

**Conduct scientific investigations using accepted principles of experimental design or engineering goal and analysis.**

*Enabling Objectives:*

* 1. Apply the definition to identify the major concepts of experimental design or engineering goal within the scenario of an experiment including: hypothesis, dependent variable independent variable, constants, control, repeated trials or problem identification, creating alternate solutions, prototyping, testing, and redesigning.
  2. Apply concepts learned in science and math classes to analyze experiments with respect to the major concepts of experimental or engineering design, design strengths and weaknesses, and develop improved designs.
  3. Write a clear and precise set of procedures.
  4. Apply information learned in science and math courses and use technology available at the school to construct appropriate data tables and graphs for various types of scientific data.
  5. Describe the relationship between variables depicted on a graph.
  6. Develop and discuss ethical guidelines for research projects.

COMPETENCY II

**Gather and analyze relevant background information.**

*Enabling Objectives:*

1. Identify relevant library, database, and web resources for specific research problems.
2. Effectively use relevant library, database, and web resources for research and information.
   1. Use search engines to find information on various topics.
   2. Explain strengths and weaknesses of various search engines.
   3. Demonstrate proficiency using advanced search engines.
   4. Properly use and cite information taken from a variety of sources.
   5. Recognize and distinguish between different types of websites.
3. Use professionals in industry or academia as resource people for research project information as necessary and document these contacts.
4. Obtain the most relevant articles and books found in library and internet searches.
5. Analyze articles and books for information relevant to a specific research problem and take notes from them, using proper documentation.

COMPETENCY III

**Complete the steps necessary to design, implement, and analyze a complex experiment or engineering goal.**

*Enabling Objectives:*

1. Design a complex experiment which includes repeated measures over time or subjects, one or more independent variables, and correlation of variables.
2. Successfully meet the established time lines for the performance objectives.
3. Maintain a current, organized, and accurate laboratory logbook.
4. Construct appropriate data tables and graphs for data derived from your experiment.
5. Apply concepts of inferential and descriptive statistics to support conclusions from the experiment.
6. Participate in the RVGS Project Forum and, if appropriate, in the district, regional, state, and international science fairs, and the annual VJAS meeting.

COMPETENCY IV

**Create a project display board or poster to depict the work done on the project for use at Project Forum.**

*Enabling Objectives:*

* 1. All content should be easily read on the board and free of spelling and grammatical errors.
  2. All components of the board should be clearly labeled with appropriate headings (Introduction, Purpose, etc.).
  3. All graphs and photographs should be clearly labeled with appropriate annotations and citations when necessary.
  4. The name of the student should **not** appear anywhere on the display.
  5. Size specifications for project display board (ISEF regulations) are followed.

COMPETENCY V

**Write a formal research paper.**

*Enabling Objectives:*

1. Create an integrated document with graphs, tables, diagrams, and/or photos.
2. Clearly describe the problem/question addressed in the experiment.
3. Synthesize information from peer-reviewed scientific papers to write a Literature Review.
4. Present methods in a way that allows replication of the experiment.
5. Clearly identify constants and controls used in the experiment.
6. Concisely present results in graphs, tables, and/or pictures.
7. Analyze results. When appropriate, use statistics as a tool to interpret findings.
8. Summarize the major findings of the experiment.
9. Discuss limitations to your experiment and interpretation of results and offer improvements to your experiment.

COMPETENCY VI

**Create a presentation of the research project and present the research to classmates or at a scientific meeting.**

*Enabling Objectives:*

* 1. Incorporate text and graphics into a presentation.
  2. Add appropriate transitions between elements in a slide and transitions between slides.
  3. Effectively use color for backgrounds and text to add visual value.
  4. Organize key points so that the presentation flows logically and is easy to follow.
  5. Use proper enunciation, pronunciation, pace, and volume in communicating the research to one’s peers.

COMPETENCY VII

**Understand the basic concepts and societal applications of synthetic biology.**

*Enabling Objectives:*

1. Describe the central dogma.
2. Define biotechnology.
3. Understand how metabolic pathways can be manipulated to create a useful product such as beta-carotene.
4. Evaluate the arguments on both sides of the controversy surrounding the use of Golden Rice.
5. Analyze the imperfect results of an experiment to engineer *Saccharomyces cerevisiae* to produce beta-carotene and analyze the metabolic pathway to generate hypotheses about the cause.
6. Extract DNA from yeast, perform PCR, and agarose gel electrophoresis.
7. Describe how PCR works.
8. Describe how agarose gel electrophoresis works and analyze the results.
9. Find and discuss current news articles related to biotechnology. Evaluate the societal and ethical implications of new technology.

COMPETENCY VII

**Discuss the uses of model organisms and their applications in biotechnology.**

*Enabling Objectives:*

1. Describe the practical features of bacteria and yeast that make them useful model organisms and tools in biotechnology.
2. Explain why Arabidopsis is a useful model organism how is it used in biotechnology.
3. Describe the advantages of using *Drosophila* and *C. elegans* as model organisms for human disease.
4. Discuss the practical features of using zebra fish embyros as models for human development.