

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Overview:** In this unit students will develop a conceptual understanding of biotechnology and bioinformatics using hands-on instruction, interactive note booking, observations of and interactions with natural phenomena and the use of engineering and design processes to identify problems, plan, test and revise possible solutions. Students are also expected to use these practices to demonstrate understanding of the core ideas while independently using their learning to analyze authentic computer databases (BLAST, OMIM, NCBI) as well as have optimum skills to potentially be employed in a working molecular biology lab.

Overview	Standards for Science	Unit Focus	Essential Questions
<p style="text-align: center;"><a href="#"><u>Unit 4</u></a></p> <p><b>Biotechnology and Bioinformatics</b></p>	<ul style="list-style-type: none"> <li>• <b>HS-LS3-1</b></li> <li>• <b>HS-LS4-1</b></li> <li>• <b>HS-LS4-2</b></li> <li>• <b>HS-LS4-3</b></li> <li>• <b>HS-LS4-6</b></li> <li>• <b>WIDA 1, 4</b></li> </ul>	<ul style="list-style-type: none"> <li>• use sterile techniques to successfully culture, work with and dispose of bacteria.</li> <li>• perform a lab that utilizes restriction enzymes to cut DNA.</li> <li>• discern different viewpoints from authentic resources.</li> <li>• interpret the vast amount of data available through these resources.</li> <li>• input short sequences of DNA from unknown origin into various databases in order to identify sequence(s).</li> <li>• formulate a hypothetical problem that can be solved using new and emerging technologies.</li> </ul>	<ul style="list-style-type: none"> <li>• Why are bacteria the preferred host for biotechnology research?</li> <li>• How is bacteria handled and successfully cultured in a laboratory?</li> <li>• How can genes be inserted into bacteria?</li> <li>• How can various vectors deliver genes into a bacterial host?</li> <li>• How can you specifically direct the insertion of genes into a plasmid?</li> <li>• How have GMOs changed our society?</li> </ul>
<p><i>Unit 4: Enduring Understandings</i></p>	<ul style="list-style-type: none"> <li>• Bacteria are a ubiquitous model for biotechnology research.</li> <li>• Exogenous genes can be easily inserted into bacteria to produce a recombinant/transgenic organism.</li> <li>• Genetically modified organisms are the norm in modern agriculture and other industries.</li> <li>• National and international databases are an important research and reference tool for a biotechnologist.</li> <li>• The field of biotechnology is ever changing and evolving with new and emerging techniques, technology, and experimental protocols.</li> </ul>	<ul style="list-style-type: none"> <li>• Why do GMOs create controversy?</li> <li>• How can GMO product(s) be identified by using biotechnology strategies?</li> <li>• What information obtained from databases can be used to assist the geneticist with their research?</li> <li>• How can we apply the information obtained from databases to evolutionary biology, medicine, comparative genetics, and genetic research?</li> <li>• How do you evaluate which biotechnology/techniques, current and/or emerging, to utilize when designing a specific experiment?</li> </ul>	

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

Curriculum Unit 4	Standards		Pacing	
			Days	Unit Days
<b>Unit 4: Biotechnology and Bioinformatics</b>	<b>HS-LS3-1</b>	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	4	24
	<b>HS-LS4-1</b>	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	4	
	<b>HS-LS4-2</b>	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.	4	
	<b>HS-LS4-3</b>	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.	4	
	<b>HS-LS4-6</b>	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.	4	
	Assessment, Re-teach and Extension		2	
	Final Exam		2	

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

Unit 4 - Human Genetics Lab CP		
Disciplinary Core Ideas	Indicator #	Indicator
<p><b>LS3.A: Inheritance of Traits</b>  Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)</p> <p><b>LS4.A: Evidence of Common Ancestry and Diversity</b>  Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)</p> <p><b>LS4.B: Natural Selection</b>  Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2)(HS-LS4-3)  The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)</p> <p><b>LS4.C: Adaptation</b>  Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)  Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3)  Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)  Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-6)</p>	<b>HS-LS3-1</b>	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
	<b>HS-LS4-1</b>	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
	<b>HS-LS4-2</b>	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
	<b>HS-LS4-3</b>	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
	<b>HS-LS4-6</b>	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Unit 4 – Human Genetics Lab CP**

**Assessment Plan**

<ul style="list-style-type: none"> <li>• Exploratory activities</li> <li>• Warm-up/Ticket Out activities</li> <li>• Class discussions</li> <li>• Student Participation</li> <li>• Teacher Observations</li> <li>• Virtual/Hands-On Labs</li> <li>• Self-Test Assessments</li> <li>• Scientist Timeline Activity</li> <li>• Clinical Case Study Analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Quizzes and Tests (Chapter 19 and 20 of Textbook, “Genetics: A Conceptual Approach, 6<sup>th</sup> edition by Benjamin A. Pierce)</li> <li>• Authentic assessments and projects</li> <li>• Exploratory activities</li> <li>• Presentations</li> <li>• Lecture Notes</li> <li>• Think-Pair-Share</li> <li>• Graphic Organizers</li> <li>• Study Questions at the end of each chapter</li> <li>• Multiple Choice and Critical Thinking at the end of each chapter</li> </ul>
<b>Resources</b>	<b>Activities</b>

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

- Chromebooks
- Textbook (“Genetics: A Conceptual Approach, 6<sup>th</sup> ed by Benjamin A. Pierce)
- Web Quests
- Virtual Field Trips
- Video Streaming
- [BrainPOP](#)
- [Puzzlemaker: Game Based Learning | Discovery Education](#)

Diversity, Equity & Inclusion Educational Resources  
<https://www.nj.gov/education/standards/dei/>

- Use various forms of expository writing-procedural writing, narrative writing, descriptive writing, labeling, as well as to create visuals, graphs, tables, diagrams and charts.
- Use scientific argumentation with exercises on writing claims, using evidence to support your claim and explaining the reasoning behind their claim.
- Mini-lessons
- Independent reading
- Films
- Website exploration
- Discussions, dialogues
- Debates
- Laboratory experiments
- Partner or small group work
- Student presentations, reports, journals, reflections
- In-class assessments
- Written reports, essays, research, and homework

*Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.*

- Microbiology Techniques (i.e. culturing, swabbing, and aseptic techniques) – A, M
- Serial Dilution Lab – A, M, T
- pGLO (or any equivalent transformation lab) – A, M, T
- Carolina – Advanced Conjugation Lab – A, M, T
- Carolina – Transduction Lab – A, M, T
- Carolina Biological - GMO Lab or Edvotek #962 – Identification of Genetically Modified Foods using PCR– A, M, T
- BLAST search Lab (Bioinformatics) - (NCBI/OMIM resources)/Computer exercises that demonstrate comparative bioinformatics showing interspecies homology – A, M, T
- DNA Fingerprinting (lab and/or worksheets) – A, M, T

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

- Edvotek #957 - DNA Damage and Repair Lab – A, M, T
- Edvotek #271 – AIDS Kit 1: Simulation of HIV Detection by ELISA test – A, M, T
- Wards Science – DNA Detectives (Restriction Enzymes and/or equivalent lab) – A, M, T
- Recombinant Paper Plasmids Lab – Recombinant DNA and Biotechnology by Helen Kreuzer and Adrienne Massey – A, M
- Restriction Analysis Challenge - Recombinant DNA and Biotechnology by Helen Kreuzer and Adrienne Massey– A, M, T
- Restriction Enzyme Site Mapping Activity – M, T • CRISPR research project – A, M, T
- Edvotek #315 – In Search of the Sickle Cell Gene (Southern Blot) Lab – A, M, T
- GMO crops/organisms – A, M, T
- Research Paper/Journal articles – A, M, T
- Video - The Island (discussion) – A, M
- Video – GATTACA (discussion) – A, M
- Video – Store Wars – A, M

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Instructional Best Practices and Exemplars**

1. Identifying similarities and differences
2. Summarizing and note taking
3. Reinforcing effort and providing recognition
4. Homework and practice
5. Nonlinguistic representations

6. Cooperative learning
7. Setting objectives and providing feedback
8. Generating and testing hypotheses
9. Cues, questions, and advance organizers
10. Manage response rates

**9.1 Personal Financial Literacy, 9.2 Career Awareness, Exploration, Preparation and Training & 9.4 Life Literacies and Key Skills**

The implementation of the 21st Century skills and standards for students of the Winslow Township District is infused in an interdisciplinary format in a variety of curriculum areas that include, English language Arts, Mathematics, School Guidance, Social Studies, Technology, Visual and Performing Arts, Science, Physical Education and Health, and World Language.

Additional opportunities to address 9.1, 9.2 & 9.4:

**Philadelphia Mint**

<https://www.usmint.gov/learn/kids/resources/educational-standards>

**Different ways to teach Financial Literacy.**

<https://www.makeuseof.com/tag/10-interactive-financial-websites-teach-kids-money-management-skills/>

- 9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.
- 9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
- 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
- 9.4.12.DC.1: Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content (e.g., 6.1.12.CivicsPR.16.a).
- 9.4.12.DC.2: Compare and contrast international differences in copyright laws and ethics.
- 9.4.12.DC.7: Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Modifications for Special Education/504**

***Students with special needs:*** The students' needs will be addressed on an individual and grade level using a variety of modalities. Accommodations will be made for those students who need extra time to complete assignment. Support staff will be available to aid students related to IEP specifications. 504 accommodations will also be attended to by all instructional leaders. Physical expectations and modifications, alternative assessments, and scaffolding strategies will be used to support this learning. The use of Universal Design for Learning (UDL) will be considered for all students as teaching strategies are considered.

- Small group instruction
- Audio books/ Text-to-speech platforms
- Leveled texts/Vocabulary Readers
- Leveled informational texts via online
- Modeling and guided practice
- Read directions aloud
- Repeat, rephrase and clarify directions
- Extended time as needed
- Break down assignments into smaller units
- Provide shortened assignments
- Modify testing format
- Repeat directions as needed
- Graphic organizers
- Study Guides, Study Aids and Re teaching as needed



**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Modifications for At-Risk Students**

Formative and summative data will be used to monitor student success. At first signs of failure, student work will be reviewed to determine support. This may include parent consultation, basic skills review and differentiation strategies. With considerations to UDL, time may be a factor in overcoming developmental considerations

- Audio books and Text-to-speech platforms
- Leveled texts/Vocabulary Readers
- Leveled informational texts via online
- Extended time as needed
- Read directions aloud
- Assist with organization
- Use of computer
- Emphasize/highlight key concepts
- Recognize success
- Provide timelines for work completion
- Break down multi-step tasks into smaller chunks
- Provide copy of class notes and graphic organizer

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

English Language Learners	Modifications for Gifted Students
<p>All WIDA Can Do Descriptors can be found at this link:  <a href="https://wida.wisc.edu/teach/can-do/descriptors">https://wida.wisc.edu/teach/can-do/descriptors</a></p> <p><b>Grades 9-12 WIDA Can Do Descriptors...</b></p> <p><i>Listening...</i></p> <ul style="list-style-type: none"> <li>• Process <u>recounts</u> by... <ul style="list-style-type: none"> <li>○ Categorizing perspectives of multiple speakers</li> <li>○ Identifying important information on specific event &amp; concept from lecture/presentation</li> </ul> </li> <li>• Process <u>explanations</u> by... <ul style="list-style-type: none"> <li>○ Recognizing specific language used to enhance clarity and precision</li> <li>○ Recognizing and following language related to the same event or phenomenon throughout presentations</li> </ul> </li> <li>• Process arguments by... <ul style="list-style-type: none"> <li>○ Identifying strengths, limitations, and potential biases from oral presentations</li> <li>○ Organizing claims and counter claims presented in debates</li> </ul> </li> </ul> <p><i>Speaking...</i></p> <ul style="list-style-type: none"> <li>• <u>Recount</u> by... <ul style="list-style-type: none"> <li>○ Adjusting presentation style, degree of formality, word choice, tone, and information to the context and audience</li> <li>○ Presenting information that follows discipline specific organization (e.g., orientation to topic, sequence of events, conclusion)</li> </ul> </li> <li>• <u>Explain</u> by... <ul style="list-style-type: none"> <li>○ Providing precision and accuracy in classifications, procedures, processes, and accounts using abstraction, technical language, and a variety of active/passive verb forms</li> <li>○ Following discipline-specific organization (e.g., orienting the reader, details, conclusion) and supporting presentations with graphs, formulas, quotes or other media</li> </ul> </li> <li>• <u>Argue</u> by... <ul style="list-style-type: none"> <li>○ Organizing claims and counter claims in debates with evidence from multiple sources</li> <li>○ Negotiating differing cultural perspectives in pairs or small groups</li> </ul> </li> </ul> <p><i>Reading...</i></p> <ul style="list-style-type: none"> <li>• Process <u>recounts</u> by... <ul style="list-style-type: none"> <li>○ Analyzing and comparing how authors use language for specific purposes and audiences</li> <li>○ Identifying how authors develop and maintain cohesion by connecting ideas or events in extended texts</li> </ul> </li> <li>• Process <u>explanations</u> by...</li> </ul>	<p>Students excelling in mastery of standards will be challenged with complex, high level challenges related to the topic.</p> <ul style="list-style-type: none"> <li>• Raise levels of intellectual demands</li> <li>• Require higher order thinking, communication, and leadership skills</li> <li>• Differentiate content, process, or product according to student’s readiness, interests, and/or learning styles</li> <li>• Provide higher level texts</li> <li>• Expand use of open-ended, abstract questions</li> <li>• Critical and creative thinking activities that provide an emphasis on research and in-depth study</li> <li>• Enrichment Activities/Project-Based Learning/ Independent Study</li> </ul> <p>Additional Strategies may be located at the links:</p> <ul style="list-style-type: none"> <li>❖ <a href="#">Gifted Programming Standards</a></li> <li>❖ <a href="#">Webb’s Depth of Knowledge Levels and/or Revised Bloom’s Taxonomy</a></li> <li>❖ <a href="#">REVISED Bloom’s Taxonomy Action Verbs</a></li> </ul>

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

- Recognizing discipline-specific patterns (e.g., orienting the reader, part-whole classification, neutral/ authoritative tone)
- 
- Identifying authors' precision and accuracy in classifications, comparisons, accounts, or procedures as a result of clear language choices
- Process arguments by...
  - Evaluating word choice and nuance as tools for distinguishing facts, claims, reasoned judgment, and opinions
  - Identifying the logical connections among claims, counterclaims, reasons, and evidence

*Writing...*

- Recount by...
  - Summarizing content-related notes from lectures or readings
  - Producing research reports using multiple sources of information
- Explain by...
  - Developing ideas about phenomena with relevant and sufficient facts, extended descriptions, concrete details, or quotations
  - Maintaining discipline-specific patterns that bridge across key uses (e.g., explanation to argument in history, explanation to recount for information reports)
- Argue by...
  - Evaluating positive and negative implications associated with various positions (e.g., historical events, scientific discoveries, individuals)
  - Organizing information logically and coherently to represent contrasting views

*Oral Language...*

- Discuss by...
  - Identifying and reacting to subtle differences in speech and register (e.g., hyperbole, satire, comedy)
  - Producing coherent oral discourse appropriate to task, purpose, and audience
  - Synthesizing and sharing information from a variety of sources and perspectives

Students will be provided with accommodations and modifications that may include:

- Relate to and identify commonalities in Social Studies and science in student's home country
- Assist with organization
- Emphasize/highlight key concepts
- Teacher Modeling
- Label Classroom Materials - Word Walls

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

**Interdisciplinary Connections**

***English Language Arts/Literacy***

1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.1** (HS-LS2-1),(HS-LS2-2),(HS-LS2-6)
2. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **RST.11-12.7** (HS-LS2-6)
3. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.8** (HS-LS2-6)
4. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **RST.11-12.9** (HS-ETS1-1),(HS-ETS1-3)
5. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **WHST.9-12.2** (HS-LS2-1),(HS-LS2-2)
6. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9-12.7** (HS-LS1-3)
7. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.11-12.8** (HS-LS1-3)
8. Draw evidence from informational texts to support analysis, reflection, and research. **WHST.9-12.9** (HS-LS1-1)
9. **WIDA Standards 1** English language learners communicate for social and instructional purposes within the school setting
10. **WIDA Standards 4** English language learners communicate information, ideas, and concepts necessary for academic success in the content area of science
11. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. **SL.11-12.5** (HS-LS1-2)

**Winslow Township School District**  
**Human Genetics Lab CP (Semester Course)**  
**Unit 4: Biotechnology and Bioinformatics**

***Mathematics***

1. Reason abstractly and quantitatively. **MP.2** (HS-LS2-1),(HS-LS2-2),(HS-LS2-6)
2. Model with mathematics. **MP.4** (HS-LS2-1),(HS-LS2-2)
3. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.1** (HS-LS2-1),(HS-LS2-2)
4. Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.2** (HS-LS2-1),(HS-LS2-2)
5. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSN.Q.A.3** (HS-LS2-1),(HS-LS2-2)
6. Represent data with plots on the real number line. **HSS-ID.A.1** (HS-LS2-6)
7. Understand statistics as a process for making inferences about population parameters based on a random sample from that population. **HSS-IC.A.1** (HS-LS2-6)

**Integration of Computer Science and Design Thinking NJSL 8**

- 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
- 8.1.12.DA.2: Describe the trade-offs in how and where data is organized and stored.
- 8.2.12.ITH.1: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints.
- 8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.
- 8.2.12.ITH.3: Analyze the impact that globalization, social media, and access to open source technologies has had on innovation and on a society's economy, politics, and culture.
- 8.2.12.ETW.2: Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.
- 8.2.12.EC.1: Analyze controversial technological issues and determine the degree to which individuals, businesses, and governments have an ethical role in decisions that are made.
- 8.2.12.EC.2: Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded.
- 8.2.12.EC.3: Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience.
- 8.2.12.ETW.4: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints.