Unit 6: Gene Expression and Regulation (Life Science)

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Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

AP Biology

Unit 6: Gene Expression and Regulation

Belleville Board of Education

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Unit Overview

Progressing from the continuity of life to gene expression, in Unit 6 students gain in-depth knowledge about nucleic acids and their role in gene expression. Students receive a finer focus on the comparison between the structures of DNA and RNA. This unit highlights how an individual's genotype is physically expressed through that individual's phenotype. Understanding protein synthesis (transcription and translation) is vital to answering essential questions about gene expression. Regulation of gene expression and cell specialization are instrumental in ensuring survival within an individual and across populations.

Enduring Understanding

- **TOPIC 6.1 DNA and RNA Structure-**Heritable information provides for continuity of life.
- **TOPIC 6.2 Replication-** Heritable information provides for continuity of life.
- **TOPIC 6.3 Transcription and RNA Processing-** Heritable information provides for continuity of life.
- **TOPIC 6.4 Translation-** Heritable information provides for continuity of life.
- **TOPIC 6.5 Regulation of Gene Expression-**Differences in the expression of genes account for some of the phenotypic differences between organisms.
- **TOPIC 6.6 Gene Expression and Cell Specialization-**Differences in the expression of genes account for some of the phenotypic differences between organisms.
- **TOPIC 6.7 Mutations-**The processing of genetic information is imperfect and is a source of genetic variation.
- **TOPIC 6.8 Biotechnology-**Heritable information provides for continuity of life.

Essential Questions

- How does gene regulation relate to the continuity of life?
- How is a species' genetic information diversified from generation to generation?
- How do living systems store, retrieve, and transmit genetic information critical to life processes?
- How does the expression of genetic material control cell products which, in turn, determine the metabolism and nature of the cell?
- How can humans use genetic engineering techniques to manipulate genetic information? What are ethical issues raised by the application of these techniques?

Exit Skills

By the end of AP Biology Unit 6, Gene Expression and Regulation, the student should be able to:

- Describe the structures involved in passing hereditary information from one generation to the next.
- Describe the characteristics of DNA that allow it to be used as the hereditary material.
- Describe the mechanisms by which genetic information is copied for transmission between generations.
- Describe the mechanisms by which genetic information flows from DNA to RNA to protein.
- Describe how the phenotype of an organism is determined by its genotype.
- Describe the types of interactions that regulate gene expression.
- Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism.
- Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.
- Describe the various types of mutation.
- Explain how changes in genotype may result in changes in phenotype.
- Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.
- Explain the use of genetic engineering techniques in analyzing or manipulating DNA.

New Jersey Student Learning Standards (NJSLS-S)

NextGen Science Standards

SCI.9-12.HS-LS1-1	Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
SCI.9-12.HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
9-12.HS-LS1-2.2.1	Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
9-12.HS-LS1-2.4.1	Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.
9-12.HS-LS1-1.6.1	Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
9-12.HS-LS1-1.6.1	students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.
9-12.HS-LS1-1.LS1.A.1	Systems of specialized cells within organisms help them perform the essential functions of life.
9-12.HS-LS1-2.LS1.A.1	Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
9-12.HS-LS1-1.LS1.A.2	All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Interdisciplinary Connections

LA.RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.9-10.2	Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
LA.RST.9-10.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
LA.RST.9-10.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual

	form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LA.RST.9-10.8	Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
LA.RST.9-10.9	Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
LA.WHST.9-10.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
LA.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.

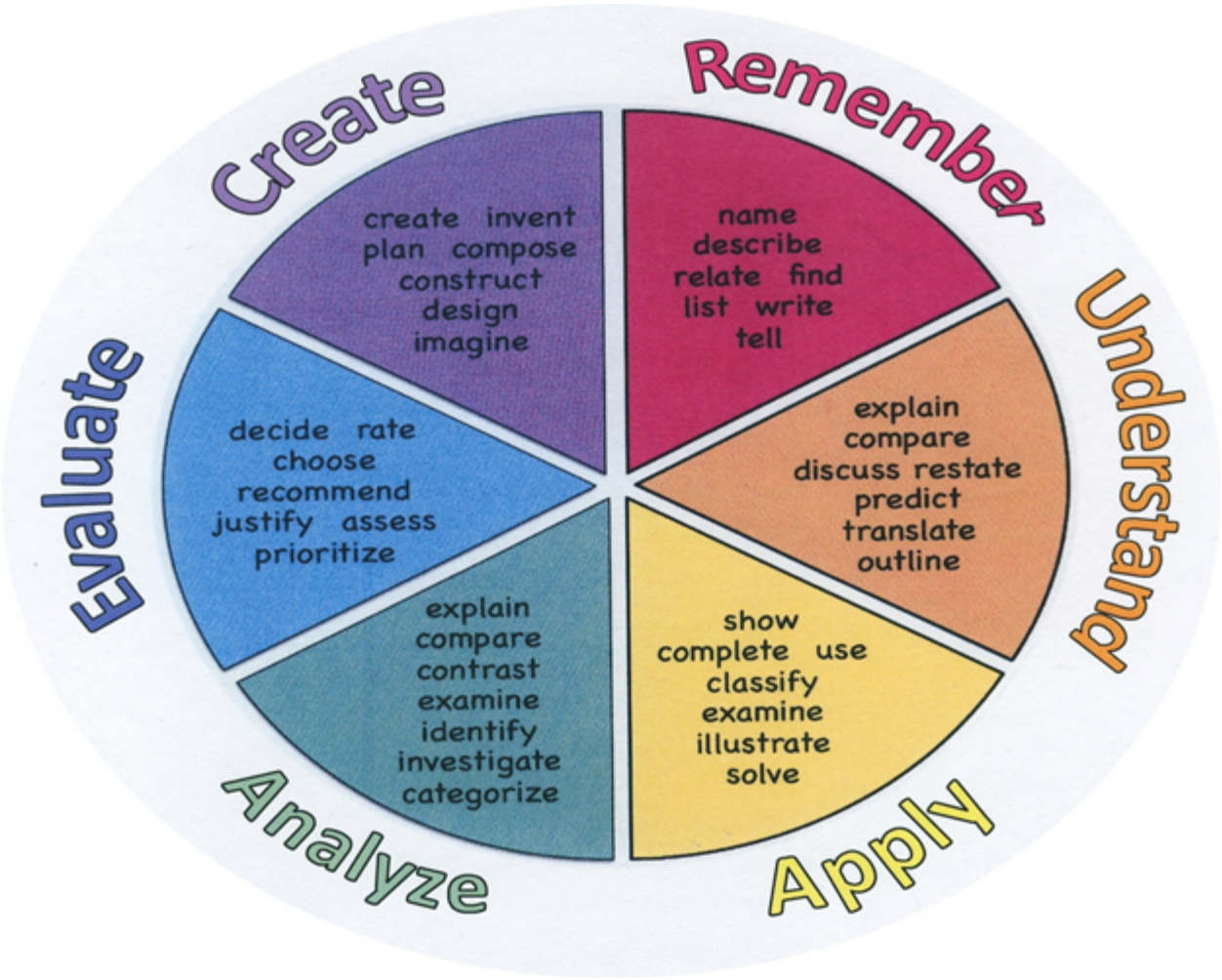
Learning Objectives

- SWDAT construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information.
- SWDAT justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information.
- SWDAT describe representations and models that illustrate how genetic information is copied for transmission between generations.
- SWDAT describe representations and models illustrating how genetic information is translated into polypeptides.
- SWDAT create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced.
- SWDAT predict how a change in a specific DNA or RNA sequence can result in changes in gene expression.
- SWDAT describe the connection between the regulation of gene expression and observed differences between different kinds of organisms.
- SWDAT describe the connection between the regulation of gene expression and observed differences between individuals in a population.
- SWDAT explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function.
- SWDAT use representations to describe how gene regulation influences cell products and function.
- SWDAT refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues, and organs.
- SWDAT justify a claim made about the effect(s) on a biological system at the molecular, physiological, or organismal level when given a scenario in which one or more components within a negative regulatory system is altered.
- SWDAT explain how signal pathways mediate gene expression, including how this process can affect protein production.
- SWDAT use representations to describe mechanisms of the regulation of gene expression.
- SWDAT justify the claim that humans can manipulate heritable information by identifying at least two commonly used technologies.
- SWDAT explain the connection between genetic variations in organisms and phenotypic variations in populations.
- SWDAT predict the effects of a change in an environmental factor on the genotypic expression of the phenotype.

Action Verbs: Below are examples of action verbs associated with each level of the Revised Bloom's Taxonomy.

Remember	Understand	Apply	Analyze	Evaluate	Create

Choose	Classify	Choose	Categorize	Appraise	Combine
Describe	Defend	Dramatize	Classify	Judge	Compose
Define	Demonstrate	Explain	Compare	Criticize	Construct
Label	Distinguish	Generalize	Differentiate	Defend	Design
List	Explain	Judge	Distinguish	Compare	Develop
Locate	Express	Organize	Identify	Assess	Formulate
Match	Extend	Paint	Infer	Conclude	Hypothesize
Memorize	Give Examples	Prepare	Point out	Contrast	Invent
Name	Illustrate	Produce	Select	Critique	Make
Omit	Indicate	Select	Subdivide	Determine	Originate
Recite	Interrelate	Show	Survey	Grade	Organize
Select	Interpret	Sketch	Arrange	Justify	Plan
State	Infer	Solve	Breakdown	Measure	Produce
Count	Match	Use	Combine	Rank	Role Play
Draw	Paraphrase	Add	Detect	Rate	Drive
Outline	Represent	Calculate	Diagram	Support	Devise
Point	Restate	Change	Discriminate	Test	Generate
Quote	Rewrite	Classify	Illustrate		Integrate
Recall	Select	Complete	Outline		Prescribe
Recognize	Show	Compute	Point out		Propose
Repeat	Summarize	Discover	Separate		Reconstruct
Reproduce	Tell	Divide			Revise
	Translate	Examine			Rewrite
	Associate	Graph			Transform
	Compute	Interpolate			
	Convert	Manipulate			
	Discuss	Modify			
	Estimate	Operate			
	Extrapolate	Subtract			
	Generalize				
	Predict				



Suggested Activities & Best Practices

1. Provided with evidence relating to how the Frederick Griffith and HersheyChase experiments supported the identification of DNA as the genetic material, students pose questions that remained unanswered by these historical experiments.

2. The Watson and Crick Model of DNA. Students develop a model of the structure of DNA based solely on Watson and Crick's original Nature article, "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid."

3. Using diagrams of nucleotides that can be found on the internet and photocopied, students can model the process of replication, explaining what is happening as they go. Teacher assesses their understanding by observing the results of replication that students produce.

4. Students build a model of transcription using pool noodles that can be purchased at a dollar store. Using everyday materials, such as tape, colored paper, yarn (or string), and markers, they identify the promoter region, TATA box, transcription start site, and terminal sequence. They describe the process of transcription from the initial binding of the transcription factors to the production of the transcript.

5. Students develop a skit to demonstrate the process of translation. Once they have an understanding of the process, challenge them to act out what might happen if there were a change in the DNA sequence or if one of the needed components was unavailable.

Debrief by having students explain the rationale for the modifications they made in their skit.

6. Students create a board game to take players through the key steps in translation — and have classmates play the game!

7. Provided with incomplete diagrams (or diagrams with errors) illustrating the structures of DNA and RNA, DNA replication, transcription, and translation, students refine or revise the diagrams and share the edited versions for critical review.

8. Students use construction paper or more elaborate materials to create a model of the lac and trp operons that include a regulator, promoter, operator, and structural genes. Students use the model to make predictions about the effects of mutations in any of the regions on gene expression.

9. Students create a diagram to distinguish between the products of embryonic versus adult stem cells. What are some arguments for and against embryonic stem cell research?

10. In a short written narrative, students describe one example of experimental evidence that supports the claim that different cell types result from differential gene expression in cells with the same DNA. Then, in small groups, students share and discuss their examples and distinguish between determination and differentiation.

11. Students create a mini-poster for peer review to explain several applications of genetic engineering and possible ethical, social, or medical issues raised by human manipulation of DNA.

12. **AP Biology Investigation 8: Biotechnology: Bacterial Transformation:** Students investigate how genetic engineering techniques can be used to manipulate heritable information using Escherichia coli. After learning fundamental skills, students can design their own experiments to manipulate DNA.

13. **AP Biology Investigation 9: Biotechnology: Restriction Enzyme Analysis of DNA:** Beginning with a forensic mystery, students investigate how genetic information can be used to identify and profile individuals.

Assessment Evidence - Checking for Understanding (CFU)

• Common Benchmarks (Benchmark)

• Unit tests- Unit 6 Personal Progress Check from AP Classroom (Summative)

• Quizzes-protein synthesis quiz, gene expression quiz, biotechnology quiz (Summative)

• Unit review/Test prep- Campbell and Reece chapter 16,17,18,19,20,21 study guides (Formative)

• Web-Based Assessments- google form quizzes (Formative)

• DBQ's (Formative)

• Written Reports- CER's for lab activities (Alternate)

• Surveys (Alternate)

- Admit Tickets
- Anticipation Guide
- Common Benchmarks
- Compare & Contrast
- Create a Multimedia Poster
- DBQ's
- Evaluation rubrics
- Exit Tickets- google form exit ticket
- Fist- to-Five or Thumb-Ometer
- Illustration
- Journals
- KWL Chart
- Learning Center Activities
- Newspaper Headline
- Outline
- Question Stems
- Quickwrite
- Quizzes-protein synthesis quiz, gene expression quiz, biotechnology quiz
- Red Light, Green Light
- Self- assessments
- Socratic Seminar
- Study Guide
- Surveys
- Teacher Observation Checklist
- Think, Pair, Share- large sticky posters
- Think, Write, Pair, Share
- Top 10 List
- Unit review/Test prep- Campbell and Reece chapter 16,17,18,19,20,21 study guides
- Unit tests- Unit 6 Personal Progress Check from AP Classroom
- Web-Based Assessments- google form quizzes
- Written Reports- CER's for lab activities

Primary Resources & Materials

- Campbell and Reece, AP Biology 11th Edition (2018)- Chapters 16,17,18,19,20,21

Ancillary Resources

- Pearson Education Test Prep Series for AP Biology (2017)
- AP Biology Investigative Labs- Investigation 8: Biotechnology: Bacterial Transformation
- AP Biology Investigative Labs- Investigation 9: Biotechnology: Restriction Enzyme Analysis
- Campbell and Reece chapters 16,17,18,19,20,21 study guide worksheets
- Molecular model kits or alternative (e.g., foam balls and toothpicks)
- Foglia powerpoints and review guides (www.explorebiology.com)
- PHET Interactive Simulations

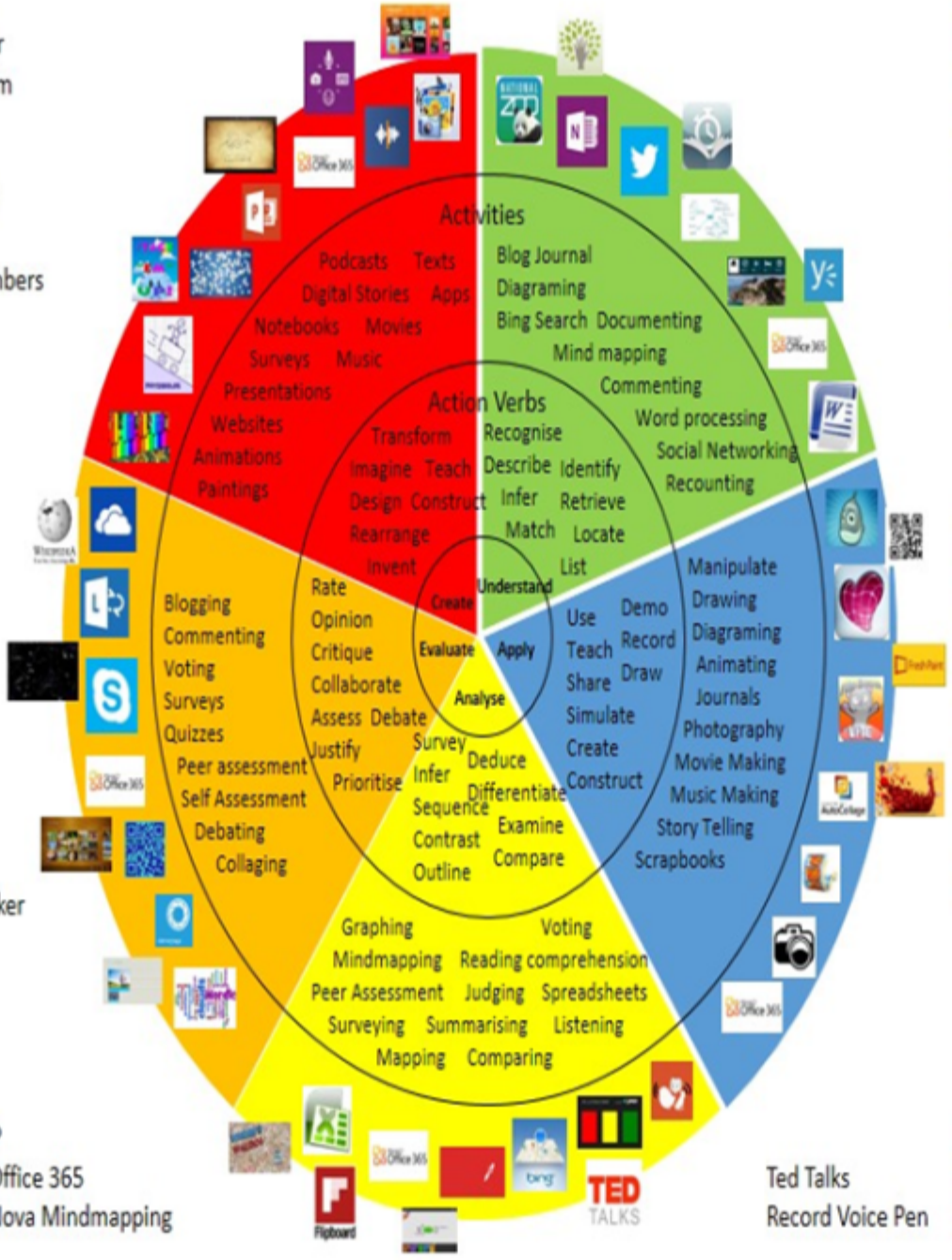
Technology Infusion

- Smart TV - (Protein synthesis, gene expression and biotechnology slideshow presentations)
- Chrome Books for Projects/ Research/ Analysis
- Youtube - Amoeba sisters videos, Mr. Anderson videos, Crash course videos
- Khan Academy videos and quizzes
- Microsoft Powerpoint
- Google Drive
- Prezi
- Ted Talks
- Ted- ED
- Microsoft Excel: graphs, charts, calculations, equations

Win 8.1 Apps/Tools Pedagogy Wheel

Podcasts
Photostory 3
Kid Story Builder
Music Maker Jam
Paint A Story
Office 365
MS PowerPoint
Stack 'Em Up
NqSquared Numbers
Physamajig
Xylophone 8

Wikipedia
Skydrive
Lync
SkyMap
Skype
Office 365
Puzzle Touch
Easy QR
Memorylage
Life Moments
Word Cloud Maker



Where's Waldo?
MS Excel Office 365
Flipboard Nova Mindmapping

Ted Talks
Record Voice Pen

Originally taken from http://www.coetail.com/vzimmer/files/2013/02/iPadagogy-Wheel.001.jpg
And adapted for Windows 8.1 devices by Charlotte Beckhurst @CharBeckhurst

Alignment to 21st Century Skills & Technology

CRP.K-12.CRP2	Apply appropriate academic and technical skills.
CRP.K-12.CRP4	Communicate clearly and effectively and with reason.
CRP.K-12.CRP5	Consider the environmental, social and economic impacts of decisions.
CRP.K-12.CRP7	Employ valid and reliable research strategies.
CRP.K-12.CRP8	Utilize critical thinking to make sense of problems and persevere in solving them.
CRP.K-12.CRP11	Use technology to enhance productivity.
CAEP.9.2.12.C.1	Review career goals and determine steps necessary for attainment.
CAEP.9.2.12.C.2	Modify Personalized Student Learning Plans to support declared career goals.
CAEP.9.2.12.C.3	Identify transferable career skills and design alternate career plans.
TECH.8.1.12.B	Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.
TECH.8.1.12.C	Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
TECH.8.1.12.D	Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.
TECH.8.1.12.F	Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
TECH.8.2.12	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
TECH.8.2.12.E	Computational Thinking: Programming: Computational thinking builds and enhances problem solving, allowing students to move beyond using knowledge to creating knowledge.

21st Century Skills/Interdisciplinary Themes

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

21st Century Skills

- Civic Literacy
- Environmental Literacy
- Global Awareness
- Health Literacy

Differentiation

Differentiations:

- Small group instruction
- Small group assignments
- Extra time to complete assignments
- Pairing oral instruction with visuals
- Repeat directions
- Use manipulatives
- Center-based instruction
- Token economy
- Study guides
- Teacher reads assessments allowed
- Scheduled breaks
- Rephrase written directions
- Multisensory approaches
- Additional time
- Preview vocabulary
- Preview content & concepts
- Story guides
- Behavior management plan
- Highlight text
- Student(s) work with assigned partner
- Visual presentation
- Assistive technology
- Auditory presentations
- Large print edition
- Dictation to scribe
- Small group setting

Hi-Prep Differentiations:

- Alternative formative and summative assessments
- Choice boards
- Games and tournaments
- Group investigations
- Guided Reading
- Independent research and projects
- Interest groups
- Learning contracts
- Leveled rubrics
- Literature circles
- Multiple intelligence options

- Multiple texts
- Personal agendas
- Project-based learning
- Problem-based learning
- Stations/centers
- Think-Tac-Toes
- Tiered activities/assignments
- Tiered products
- Varying organizers for instructions

Lo-Prep Differentiations

- Choice of books or activities
- Cubing activities
- Exploration by interest
- Flexible grouping
- Goal setting with students
- Jigsaw
- Mini workshops to re-teach or extend skills
- Open-ended activities
- Think-Pair-Share
- Reading buddies
- Varied journal prompts
- Varied supplemental materials

Special Education Learning (IEP's & 504's)

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content

- modified test format
- modified test length
- multiple test sessions
- multi-sensory presentation
- preferential seating
- preview of content, concepts, and vocabulary
- Provide modifications as dictated in the student's IEP/504 plan
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

English Language Learning (ELL)

- teaching key aspects of a topic. Eliminate nonessential information
- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

At Risk

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards,

charts, graphs, slide shows, videos, etc.) to demonstrate student's learning

- allowing students to select from given choices
- collaborating (general education teacher and specialist) to modify vocabulary, omit or modify items to reflect objectives for the student, eliminate sections of the test, and determine how the grade will be determined prior to giving the test.
- decreasing the amount of workpresented or required
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using videos, illustrations, pictures, and drawings to explain or clarify

Talented and Gifted Learning (T&G)

- Advanced problem-solving
- Allow students to work at a faster pace
- Cluster grouping
- Create a blog or social media page about their unit
- Create a plan to solve an issue presented in the class or in a text
- Debate issues with research to support arguments
- Flexible skill grouping within a class or across grade level for rigor
- Higher order, critical & creative thinking skills, and discovery
- Multi-disciplinary unit and/or project
- Teacher-selected instructional strategies that are focused to provide challenge, engagement, and growth opportunities
- Utilize exploratory connections to higher-grade concepts
- Utilize project-based learning for greater depth of knowledge

Sample Lesson

Unit Name: Unit 6: Gene Expression and Regulation

NJSLS: Attached

Interdisciplinary Connection: Art (building models)

Statement of Objective: SWDAT create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced.

Anticipatory Set/Do Now: Mutation vocabulary matching review

Learning Activity: Using construction paper, markers, and scissors, students construct a model of DNA using at least 24 nucleotides. Students use the model to distinguish between DNA and RNA; to model the processes of replication,

transcription, and translation; and to predict the effects of change (mutation) on the original nucleotide sequence.

Student Assessment/CFU's: Use rubric to assess accuracy of models

Materials: Smart TV for anticipatory set, chrome books for exit ticket

21st Century Themes and Skills: Health and Environmental Literacy

Differentiation/Modifications: Visual Representation, extra time for task completion

Integration of Technology: Google Classroom for resources and homework assignments

SCI.9-12.HS-LS1-1	Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.