BALTIMORE CITY
PUBLIC SCHOOLS

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Senior Project
Science

2020 Senior Project

Life Science

Student Packet

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Student Name

Salmon Evolution

The student will use data from a gel electrophoresis of fish protein to determine the

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PROJECT TASK

The student will use data from a gel electrophoresis of fish protein to determine the relatedness of four species of salmon.

DIRECTIONS

1. Read the Scenario.
2. Read through the Project Steps.
3. Review the categories in the Project Scoring Criteria.
4. Determine a timeline for completing the project with your teacher. The teacher and student will specify dates for each CHECK POINT listed in the Project Steps.
5. Complete the Project Steps.
6. Submit all completed project documents to your teacher by the agreed upon due date.

PROJECT COMPLETION REQUIREMENTS

1. Answerable scientific question
2. Research (including at least two summarized references)
3. The relationship between DNA and protein synthesis
4. Evidence that the simulation was conducted by the student
   - Data and observations obtained during the simulation
   - Electronic or hand-drawn image of the completed gel that appears on the screen
5. Testable hypothesis
6. List of materials
7. Possible sources of error clearly identified
8. Lab procedure
9. Data table
10. Analysis of data supported by evidence from investigation
11. Confirmation, modification, or rejection of hypothesis
12. Summary and conclusion statements

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Weekly Plan

Week 1	☐ Develop a meaningful, answerable scientific question related to the scenario. ☐ Provide a written comparison of the salmons' physical features, habitats, and ranges. ☐ You should include images, and at least two references. With each reference, you should summarize the relevant information from each reference.
Week 2	☐ Explain how the variation in proteins reflects changes in a species DNA. ☐ Complete the simulation of gel electrophoresis. ☐ Sketch the gel or print a "screen shot" as evidence of having viewed the simulation. ☐ State the approximate lengths of the DNA strands in the DNA sample. ☐ Explain how you determined the length of strands and express the lengths of the strands using scientific notation.
Week 3	☐ Write a hypothesis about which of the four species of salmon are most closely related. ☐ Select the materials needed for you investigation and record them in your journal. ☐ Identify and explain the following for performing gel electrophoresis: • Possible sources of error • Safety precautions and equipment ☐ Write a procedure for your proposed investigation.
Week 4	☐ Organize the data in the Electrophoresis Simulation Sheet into a table (Follow the directions). ☐ Use the data to determine the relatedness of the salmon (Follow the directions). ☐ Write your response in your journal.
Week 5	☐ Use your data to confirm, reject, or modify your hypothesis.
Week 6	☐ Use information from the investigation and your research to explain how these different salmon populations evolved over time (Follow the directions).

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Standards

LS1.A	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. (secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)
LS3.A	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.
LS3.B	Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.
LS4.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.
LS4.C	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.

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SCENARIO

A student was researching different types of salmon found in the world. She discovered that most salmon live in the Pacific Ocean. She wondered if the Atlantic Salmon was actually related to the salmon found in the Pacific Ocean. The student knows that using the common names of fish is not always an accurate way to classify them. The student wonders if she could do an investigation that would show how closely these salmon are related.

PROJECT STEPS

1. Pose a meaningful, answerable scientific question related to the scenario.
   (See Category 1 in the Project Scoring Criteria.)

2. Salmon have a similar body shape but can usually be identified based on coloration and anatomical features. Use available resources to research information about the salmon listed below:

   - Atlantic
   - Coho (Silver)
   - Chinook (King, Spring)
   - Pink (Humpback)

   Provide a written comparison of the salmons' physical features, habitats, and ranges. Be sure to list characteristics that could be used to distinguish among them. Write your comparisons in your journal. You should include digital images of the salmon in your journal.

   Cite at least two references and summarize the relevant information from each reference. These may be Internet-based references, print references, or a taped interview with a scientist working in the field.
   (See Category 3 and Category 5 in the Project Scoring Criteria.)

   CHECK POINT **DATE**_____

3. Species that diverged from a common ancestor a long time ago are less similar than those that diverged more recently. The degree of relatedness among species can be estimated by the number of differences in an organism's proteins. Explain how the variation in proteins reflects changes in a species DNA. In your response, be sure to include (but do not limit yourself to) information regarding
   - The structure of DNA
   - The definition of a gene
   - The role of DNA in the storage of genetic information
   - The roles of DNA and RNA in protein formation
   - How mutations might affect the traits of an animal

   (See Category 3 and Category 5 in the Project Scoring Criteria.)

4. Even though the salmon look similar, the degree of relatedness among them can be determined by protein analysis. Part of this analysis involves gel electrophoresis. Protein and DNA gel electrophoresis follow the same basic procedures when making and running the gel; the difference is in the sample added to the wells before running the electrophoresis.

   Complete the simulation of gel electrophoresis at the Internet address provided below to learn how to make and run a gel electrophoresis.

   http:/ learn.genetics.utah.edu/content/labs/gel/

   Sketch the gel or print a "screen shot" as evidence of having viewed the simulation. State the approximate lengths of the DNA strands in the DNA sample. Explain how you determined the lengths of the strands. Express the lengths of the strands using scientific notation.

   (See Category 2, Category 3, and Category 4 in the Project Scoring Criteria.)

   CHECK POINT **DATE**_____

5. Based on your research and your knowledge of evolution, write a hypothesis about which of the four species of salmon are most closely related. Record your hypothesis in your journal.

   (See Category 1 in the Project Scoring Criteria.)

6. Select the materials needed for your investigation from the list below. Some of these materials may not be appropriate for your investigation, and you may add to the list. Include this list in your journal.

Materials

- Agarose
- Apron
- Blender
- Buffer
- Electrophoresis box
- Flask
- Fluorescent light
- Gel comb
- Gel mold
- Gloves
- Goggles
- Ice
- Liquid buffer
- Loading buffer
- Loading dye
- Metric ruler
- Micropipette
- Microwave
- Pipette tips
- Power supply
- Protein samples
- Protein size standard
- Protein staining solution
- Scalpel
- Staining solution
- Ultraviolet light box

(See Category 1 in the Project Scoring Criteria.)

7. Identify and explain the following for performing gel electrophoresis:
   - Possible sources of error
   - Safety precautions and equipment

   (See Category 2 in the Project Scoring Criteria.)

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8. Write a procedure for your proposed investigation.
   (See Category 1 and Category 2 in the Project Scoring Criteria.)

   CHECK POINT **DATE**_____

9. Scientists have analyzed the proteins from the four species of salmon. The gel electrophoresis is given on the *Electrophoresis Simulation Sheet.*

   Organize the data in the *Electrophoresis Simulation Sheet* into a table that shows the:
   - Number of common proteins among the different salmon
   - Proportion of proteins each salmon has in common with the other; use a calculator or computer to calculate the proportion

   (See Category 2, Category 3, and Category 4 in the Project Scoring Criteria.)

10. Use the data to determine the relatedness of the salmon. Be sure to
    - State which specimens are most and least closely related
    - Explain how the differences in the proteins would cause a difference in the gel bands on the electrophoresis gel
    - Support your statement with data from the simulation sheet and data table

    Write your response in your journal.
    (See Category 1, Category 2, Category 3, and Category 5 in the Project Scoring Criteria.)

    CHECK POINT **DATE**_____

11. Use your data to confirm, reject, or modify your hypothesis.
    (See Category 2 in the Project Scoring Criteria.)

    CHECK POINT **DATE**_____

12. Use information from the investigation and your research to explain how these different salmon populations evolved over time. In your response, be sure to include:
    - An explanation of natural selection
    - How variation contributes to the survival of organisms
    - How environmental pressure affects natural selection and the development of unique species

    It may be necessary to conduct additional research in order to complete this task.
    (See Category 1, Category 3, and Category 5 in the Project Scoring Criteria.)

    FINAL CHECK POINT **DATE**_____

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PROJECT SCORING CRITERIA

Overview

In order to satisfactorily complete this project, the student must:

- demonstrate understanding of twenty (20) Indicators of Learning
- demonstrate understanding of at least one (1) indicator within each category

Category 1: Science Ideas and Investigative Approaches

A student must attempt to address all indicators appropriate to the project task. A student must demonstrate understanding of at least one (1) indicator in this category but may demonstrate an understanding of a maximum of four (4) indicators. Each indicator is valued at one (1) point.

Progress Check ℛ	Indicators of Learning
	The student will:
❑	pose meaningful, answerable scientific questions.
❑	formulate a working hypothesis.
❑	test a working hypothesis.
❑	select appropriate instruments and materials to conduct an investigation.
❑	identify appropriate methods for conducting an investigation (independent and dependent variables, proper controls, repeat trials, appropriate sample size, etc.).
❑	use relationships discovered in the lab to explain phenomena observed outside the laboratory.

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Category 2: Data Collection and Analysis

A student must attempt to address all indicators appropriate to the project task. A student must demonstrate understanding of at least one (1) indicator in this category but may demonstrate an understanding of a maximum of four (4) indicators. Each indicator is valued at one (1) point.

Progress Check ℛ	Indicators of Learning
	The student will:
❑	recognize safe laboratory procedures.
❑	learn the use of new instruments and equipment by following instructions in a manual or from oral direction.
❑	organize data appropriately using techniques such as tables, graphs, and webs. (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title)
❑	analyze data to make predictions, decisions, or draw conclusions.
❑	determine the sources of error that limit the accuracy or precision of experimental results.
❑	use models and computer simulations to extend his/her understanding of scientific concepts.
❑	use analyzed data to confirm, modify, or reject a hypothesis.

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Category 3: Communicating Science
A student must attempt to address all indicators appropriate to the project task. A student must demonstrate understanding of at least one (1) indicator in this category but may demonstrate an understanding of a maximum of four (4) indicators. Each indicator is valued at one (1) point.

Progress Check ℛ	Indicators of Learning
	The student will:
❑	demonstrate the ability to summarize data (measurements & observations).
❑	explain scientific concepts and processes through drawing, writing, and/or oral communication.
❑	use computers and/or graphing calculators to produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.
❑	use tables, graphs, and displays to support arguments and claims in both written and oral communication.
❑	create and/or interpret graphics (scale drawings, photographs, digital images, field of view, etc.).
❑	read a technical selection and interpret it appropriately.
❑	use, explain or construct various classification systems.
❑	describe similarities and differences when explaining concepts and/or principles.
❑	communicate conclusions derived through a synthesis of ideas.

Category 4: Science, Mathematics, and Technology
A student must attempt to address all indicators appropriate to the project task. A student must demonstrate understanding of at least one (1) indicator in this category but may demonstrate an understanding of a maximum of two (2) indicators. Each indicator is valued at one (1) point.

Progress Check ℛ	Indicator Statement
	The student will:
❑	use ratio and proportion in appropriate situations to solve problems.
❑	use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
❑	express and/or compare small and large quantities using scientific notation and relative order of magnitude.

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Category 5: Concepts of Biology

A student must attempt to address all indicators appropriate to the project task. A student must demonstrate understanding of at least one (1) indicator in this category but may demonstrate an understanding of a maximum of ten (10) indicators. Each indicator is valued at one (1) point.

Progress Check ℛ	Indicators of Learning
The student will explain how new traits may result from new combinations of existing genes or from mutations of genes in reproductive cells within a population.	
❑	natural selection *(definition)*
❑	natural selection *(effects of environmental pressure)*
❑	adaptations *(effects on survival)*
❑	variation *(effect on survival and reproductive success)*
The student will estimate degrees of relatedness among organisms or species.	
❑	classification *(recognize relationships among organisms)*
❑	anatomical similarities *(evolutionary relationships)*
❑	anatomical similarities *(homologous structures)*
❑	similarities of amino acid sequence *(including results from gel electrophoresis)*
The student will be able to describe the unique characteristics of chemical substances and macromolecules utilized by living systems.	
❑	nucleic acids *(organic molecule)*
❑	nucleic acids *(nucleotides are building blocks—sugar, phosphate, and & nitrogen bases)*
❑	nucleic acids *(DNA is a double helix)*
❑	nucleic acids *(RNA is a single strand)*
❑	nucleic acids *(DNA role in storage of genetic information)*
The student will explain how a genetic trait is determined by the code in a DNA molecule	
❑	definition of gene *(a segment of DNA that codes for a protein or RNA)*
❑	sequence of nitrogen bases directing protein formation *(role of DNA, mRNA, tRNA, rRNA)*
❑	proteins determine traits
The student will interpret how the effects of DNA alteration can be beneficial or harmful to the individual, society or the environment.	
❑	mutations

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Category 6: Miscellaneous
Students may have addressed project steps in more depth or in ways that are not anticipated. The DCI and Indicator statement should be added to the table below to document additional indicators the student has addressed. The student is not required to demonstrate understanding of indicators in this category but may demonstrate an understanding of a maximum of two (2) indicators. Each indicator is valued at one (1) point.

DCI	Indicator Statement

Number of Indicators Student Addressed in Project

Category 1		**(maximum of 4)**
Category 2		**(maximum of 4)**
Category 3		**(maximum of 4)**
Category 4		**(maximum of 2)**
Category 5		**(maximum of 10)**
Category 6		**(maximum of 2)**
Project Total		**(For successful completion of this project, the student must demonstrate an understanding of 20 Indicators of Learning.)**

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