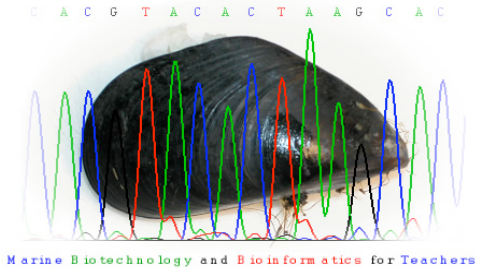

DNA, Proteins, Dissection, and Pipetting

Designed by

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Background

Bioinformatics

The broad definition of bioinformatics is the use of computer science, mathematics, and information theory to model and analyze biological systems, especially systems involving genetic material. Bioinformatics is an array of computer applications that assist with DNA and Protein analysis. Programs are designed to compare and contrast laboratory data; analyze comprehensive details to data and create reports; and provide extensive information in digital formats.

Biotechnology

The broad definition of biotechnology is simply the industrial use of living organisms (or parts of living organisms) to produce foods, drugs, or other products. Biotechnology is a branch of science that involves the study of living organisms, more often than not this involves extracting and manipulating the organism's DNA. Research conducted using biotechnology includes studies within physiology, ecology, oceanography, criminal investigation, paternity tests, agriculture, and medical fields. Because DNA is in every living organism, the use of the equipment involved in extracting DNA and reading the DNA sequence is crucial to the process.

Lesson Plan

The lessons began with a discussion of transcription and translation. Descriptions of how DNA is transcribed into mRNA and mRNA is translated into a protein (polypeptide) are presented to the students. The discussion is followed by a game of codon bingo. The initial bingo card was left blank for the students to fill in the spaces with the single letter that represents one of the 20 amino acids that make up a protein. Four rounds are typically used to help demonstrate student comprehension. In the first round students are given mRNA codons and need to identify the amino acid and cover it on their board. The second round is the same, but codons are read at a faster pace. The third round now involves transcription and translation. Students are given the three letter DNA code and have to transcribe it to the mRNA codon and then determine the amino acid that was being coded for. Finally the fourth round was the same as the third, but the students were given less time between each DNA code.

This activity relates to how DNA supplies the code for mRNA which tells which amino acids are linked together to make a protein. To support the discussion of proteins the students will look up a specific protein on the National Center for Biotechnology Information (NCBI) website. Within this website, they manipulate the protein on the computer to visually see the differences it had in a 3D format. The program they used was Cn3d. The students will work with different types of myoglobin. Once they work with the program the students will create a 3D protein structure out of candy.

To give the students the experience of working in a lab, they dissected a mussel and worked with pipettes. The objective of the dissection was to provide the students with a hands-on learning experience in a lab where they get the DNA from the organism and go through the steps of taking the tissue out of the

organism and prepare it for DNA extraction. The steps involved in this process include biotechnology and bioinformatics. This lesson is the beginning processes of a final biotech product.

To begin the process of extracting DNA the students will dissect a mussel. They will examine gill tissue and put it in extraction buffer. Once they finish their tubes will be placed in a warm water bath. To continue learning about the tissues and cells of the mussel the students will be given the opportunity to look at the different mussel tissues under a compound and dissecting microscopes.

The final activity of the day will include learning to work with micropipettes. They will be given a set of instructions and a handout with specific volumes of colored water they were supposed to insert into a 96-well plate. When they complete the worksheet correctly, they should be able to decode the secret message within the well plate: DNA.

Description of Audience: This biotechnology/bioinformatics activity is designed for use by high school students.

State Standards: Standard 4:

Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:

a. *Students know* the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.
b. *Students know* how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.
c. *Students know* how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.
d. *Students know* specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.
e. *Students know* proteins can differ from one another in the number and sequence of amino acids.
f. * *Students know* why proteins having different amino acid sequences typically have different shapes and chemical properties.

Standard 5:

The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:

a. *Students know* the general structures and functions of DNA, RNA, and protein.

National Standards: This biotechnology/bioinformatics activity fulfills the following National Science Standards:

TABLE 6.10. CONTENT STANDARDS, GRADES 9-12

UNIFYING CONCEPTS AND PROCESSES	SCIENCE AS INQUIRY	PHYSICAL SCIENCE	LIFE SCIENCE
Systems, order, and organization	Abilities necessary to do scientific inquiry	Structure of atoms	The cell
Evidence, models, and explanation	Understandings about scientific inquiry	Structure and properties of matter	Molecular basis of heredity
Change, constancy, and measurement		Chemical reactions	Biological evolution
Evolution and equilibrium		Motions and forces	Interdependence of organisms
Form and function		Conservation of energy and increase in disorder	Matter, energy, and organization in living systems
		Interactions of energy and matter	Behavior of organisms

EARTH AND SPACE SCIENCE	SCIENCE AND TECHNOLOGY	SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES	HISTORY AND NATURE OF SCIENCE
Energy in the earth system	Abilities of technological design	Personal and community health	Science as a human endeavor
Geochemical cycles	Understandings about science and techology	Population growth	Nature of scientific knowledge
Origin and evolution of the earth system		Natural resources	Historical perspectives
Origin and evolution of the universe		Environmental quality	
		Natural and human-induced hazards	
		Science and technology in local, national, and global challenges	

STEM Connection.

Discuss with the students in some detail how "microarrays" are used to screen natural plant and animal proteins to discover potential new medicines. Work on to summarize the process of modifying and re-screening these proteins to remove/minimize side-effects, and also reviewed the Clinical Trial process. The lesson will finish by mentioning the time commitment and research dollars invested to bring new medicinal treatments to the marketplace and conclude with future research budget needed for both genomics and proteomics.

Technology Integration.

PowerPoint slides will be used to introduce the lesson and describe the processes of transcription and translation.

In the computer lab, the lesson will include an introduction to the National Center for Biotechnology Information (NCBI) website where they used the NCBI protein database and image gallery using Cn3D to learn about the structure of proteins and create a 3D protein.

They also had the opportunity to view mussel tissues under a dissecting microscope and a compound microscope. Additionally, the students learned to use research-grade micropipettes.

Goals(s):

Each goal is meant to provide an authentic science related experience to each student in a fun environment. As a teacher, the set up for the lesson includes providing the material and equipment for each student and maintaining an environment where the student can learn the material in a comfortable, safe, and informative format.

- How protein is synthesized from DNA and mRNA through the processes of transcription and translation.
- Proper laboratory safety and techniques for performing a mussel dissection.
- Proper laboratory protocol for pipetting.

Learning Objective(s)

Upon completion of this lesson, students will be able to identify amino acids based on the DNA and mRNA codons. They will know how a protein is made, what it looks like, and that proteins are the building blocks of life. The students will be able to identify the organs of a mussel; they will know what the different tissue types look like under a microscope; and they will be able to properly use dissection tools. Lastly, the students will be able to manipulate a micropipette and understand that a large amount of DNA is contained in extremely small volumes.

- Identify amino acids used in protein formation through a word recognition game.
- Build protein models using student-friendly materials.
- Dissect a mussel and identify its major anatomy.
- Demonstrate accurate pipetting techniques.

Purpose/Rationale

The lesson was designed to give the students a learning experience that included interactive fun activities that support the objectives of the lesson.

The lessons meet the standards listed above in the "Background" section of this report.

Result 1 — The combination of student collaborations, questionnaires, educational games, interactive computer applications, and the experience of tangibly building their own protein structures, will give students a "big picture" understanding of the DNA->RNA->Protein relationship.

Result 2 — The hands on activities included in the wet lab result in experience and comprehension of a bivalve's anatomy, cell structure, and reproductive stages. Additional experience will be obtained with manipulating micropipetts and comprehension of how a large amount of DNA is obtained in small volumes of solution.

Materials/Resources

In order to complete this lesson, the following materials are needed: (Make a vertical list. Include quantities, resources, & websites)

The materials used in the computer lab include:

Markers or colored pencils
Codon Bingo worksheets
    Attached in Appendix 1
Bingo markers (pennies, candy, anything that covers the square identifying the amino acid)
Internet access
    NCBI: Cn3d software, which is downloaded from the NCBI webpage
Protein Structure worksheet
    Attached in Appendix 2
Materials to make a protein structure

Different kinds of candy or food items; or
Ribbons, pipe cleaners, and other nonedible craft materials; and
toothpicks

The materials used in the wet lab include:

- Dissection tools/equipment
- Mussels, clams, or some other bivalve
- Microscopes
  - Compound
  - Dissecting

- DNA secret code worksheet
  - Attached in Appendix 3
- Micropipetts: medium size
- Well plates, enough for groups of two for the class
- Micropipette tips
- Tip discard container
- Food coloring
  - Red
  - Blue
  - Yellow

End of Day Assessment Tools

- Turning Point software

Prior Teacher Preparation

In preparation for this lesson planning was needed to determine adequate time allocation for activities and material explanations. The PowerPoint slides and worksheet materials were prepared and gathered. Wet lab materials were also put together and set up in the lab.

3-Step Procedure

#1 Introduction

Student background knowledge will be assessed during introductions to activities. Teacher directed questions will be used to probe familiarity with concepts and related classroom experiences. Students will be encouraged to identify connections between prior knowledge and new material through questions and an interactive bingo game.

Power point presentations will be used to introduce the relationships of DNA, mRNA, and protein formation, as well as mussel morphology and anatomy prior to the dissection activity. Worksheets will be circulated to guide students through activities. Some will be retained by the students for their own reference; others will be collected and assessed for student understanding and teacher feedback.

Students will build models of proteins using candy and toothpicks.

#2 Exploration

Bioinformatics

Students will be grouped in teams of four to answer questions assessing background knowledge of DNA and RNA structure and function. Students will be asked to answer questions on butcher paper, using colored markers. The butcher paper will be posted and results shared with the class to build a common understanding of student background knowledge.

QUESTIONS USED: "What is DNA?" "What is RNA?"

Students will remain in teams of four to identify codon formations using a simple reading frame. Corresponding DNA sequences will be cited by teachers as prompts; students will then identify appropriate codons. (See Appendix 1).

The connections between amino acids and protein formation will be elicited through the question, "How do codons relate to protein formation?" "What is transcription?" "What is translation?" "Which comes first, transcription or translation?"

Parallels between RNA translation and language translation will be established to build familiarity with this concept.

Students will then be asked to view virtual protein models and answer questions on a worksheet (See Appendix 2).

Students will work in teams of two to build a specific protein model using candy and toothpicks. Models will be displayed for student viewing at the end of the activity.

Biotechnology

Students will work in wet lab stations in their same groups, then split into pairs for a mussel dissection activity. The dissection will be introduced with power point pictures detailing external and internal mussel anatomy features. Lab safety will be used to introduce the dissection. Background knowledge and lab experience will be assessed with the following questions: "How do you use a knife when cutting?" "What is the most important thing to remember in any lab activity?" "How many students have performed dissections before?"

Teachers will circulate among lab stations to check student understanding and to monitor student accomplishment of dissections tasks. Students will be issued a checklist of tasks to guide them through the identification of mussel organs as well as tissue extraction for later DNA analysis.

When DNA has been extracted, students will be asked to prepare microscope slides to view gonad tissue and identification of gametes.

Students will then be introduced to the process of pipetting.

#3 Application

Students gained new confidence and abilities to help complete assignments more quickly in both high school and college. Abilities included: Mental Shortcuts – solving some of the steps of a complex problem "in their heads," without needing to write each step on paper and solve it the long way; Laboratory Techniques – practicing good laboratory safety when dissecting, mounting slides with cover slips, using compound/binocular microscopes, and demonstrating the proper techniques for using research-grade micropipettes; and of course, stretching their imagination and creativity. A good follow-up might be to look at DNA-prep kits available at Qiagen or Roche. Also, give the students enough authority to "help" the science teachers at their high school find equipment, plan lessons and labs, and stock their library/computer lab with demo software like Chromas, Clustal, and Cn3D.

The "STEM Connection" described how various plant and animal proteins are screened for anti-disease properties, then modified in the laboratory to make them more appropriate for human use, and finally brought through the three-stage Clinical Trial process to bring a new medication to market.

Assessment

Various worksheets were collected and assessments were made throughout the day. A final assessment was given through a 20 questions multiple choice quiz answered using the TurningPoint student response system. Point totals were kept for all the various activities in order to check for comprehension. In looking at the assessments, our goals and learning objectives have been met. Not all of them were met to the extent we would have liked, but in a short time frame the results were positive.

Teachers' Self Evaluation

Tim Hiler
Students indicated that they had prior exposure to lab protocol and seemed familiar with safety guidelines (use of gloves, handling sharps, etc.). Students indicated that the dissection "went well" and requested that more time be allowed for use of microscopes. Students indicated that they would have preferred that microscopes be placed at individual lab tables instead of at one station. Students demonstrated an understanding of dissection and microscopy techniques.

Students had some problems with identifying mussel organs. Gonad tissue was commonly mistaken for gill tissue and vice versa.

I would modify this lesson by checking with each table to make sure that different mussel organs were clearly distinguishable before asking students to prepare microscope slides

Dawn Spencer
Overall student responses to the day's lessons were positive. Questions asked of them in the various activities were answered thoroughly and with smiles. They responded well to the activities and did everything they could to the complete the worksheets handed out and complete the labs assigned. Evaluation responses by the students included comments that stated they had fun, that they wished they had more time in the labs and more time to work on their protein structures. They were glad to hear that what we were teaching them is used in the workforce and that they could make a living in the science fields. Like the students, I wish we had more time for the activities, I felt as though I was always cutting them short and making them clean up before they were ready. Even with making them clean up before they were ready, the allotted time we had to spend with them went over. I do feel that the activities we assigned were all valid and well worth doing, so I don't know what I would take out. On the positive side, the kids were not bored and even though it was a long day they liked what they were doing and wished they had more time.

In retrospect, I feel we did a two day's lesson in one day. We started with a prior knowledge assessment, gave them information (ppt presentations); activities that supported the ppt.; told them how they could apply this into their education and career decisions; provided hands-on experiences in the wet lab; and gave a final learning assessment. Within the day, I think the variety of activities met the needs of many learning styles which is what made it interesting and fun for them and us.

Scott Spencer
These students have an almost "sponge-like" ability to soak up and retain newly-acquired knowledge. This ability caused me to rethink my STEM Careers presentation, to make it more advanced and more challenging. A few students commented that they made the abstract connection between the Clinical Trial process I discussed, and the protein coding and design project they pursued in the morning. Ironically, both teachers and students had the same complaint: not enough time to complete each activity: we actually felt bad, having to pull them away from tasks they were really enjoying. Overall, I felt we had a very good balance between various media (PowerPoint, verbal presentation, computer applications, and hands-on projects). We also had several interactive games, which included the final Assessment Quiz. We all had fun!

Scott Vander Veen
The general student response was very positive to the activities and information that was included in this lesson. The labs on dissection and pipetting had a very positive impact on the students and taught them valuable lab skills and techniques. Students were processing information and this was shown through their responses and questions. In looking back at this lesson I would probably still include all the activities that we covered but maybe in a difference sequence. The pipetting seemed out of place. Maybe it should have gone with the introduction to biotechnology. I also feel that we could have done a little better job making connections between biotechnology and proteins.

Appendix 1
Codon Bingo Worksheets

Appendix 2
Protein Structure Worksheet

Appendix 3
DNA: Pipetting the Secret Code

Appendix 4
Completed Student Worksheets
- Protein Structures
- DNA: Pipetting the Secret Code