Coupling Biomedical Techniques with Team Based Learning to promote and improve student learning success and application of the four comprehensive AP Biology Big Ideas.

Jennifer A. Lindemann

AP Biology/Biology Honors Instructor

Providence School

Duval County, Jacksonville, FL

jlindemann@prov.org

Abstract:

It is not uncommon for teachers to recognize that students do not connect prior knowledge from one unit of study in science to another unit of study later in the same course. Students often compartmentalize their knowledge rather than connect conceptual understandings. To create a level of deeper understanding and connections between units of study in Advanced Placement Biology and their relevance to each other, biomedical and biotechnical applications with team based learning (TBL) strategies will be utilized in tandem with the AP content. Students should be able to relate the response of cells in various concentrated solutions to the physiological responses of multicellular organisms in natural and extreme environmental changes. Students should then be able to correlate the relationship of the organism's physiological and behavioral response in those environments to the gene mutations that occur within the central dogma of gene to protein, form and function. Together with Team Based Learning, students applying biotechnical/medical skills to more than one unit of study, should get a birds' eye view of how microcellular processes directly affect and overall impact living organisms at the macro level.

To determine the success of students' progress in connecting the Four Big Ideas of AP Biology content, student knowledge will be measured using unit pre and post-tests that correspond with the Florida state standards. Students will be surveyed post laboratory exercises to determine their ability to relate content to application within in the four big ideas of AP Biology. Statistical analysis will be conducted to determine comprehensive learning outcomes of AP Biology students utilizing both biotechnical/biomedical and TBL skills compared to AP Biology students not exposed to these methodologies.

Rationale:

Prior to 2013, the AP Biology course was content driven and "lacked specificity about the exact tasks students would be required to perform with their biological content knowledge." As a result, the AP Biology course and exam were "redesigned [in 2012] to provide a learning experience that improves readiness for college placement and credit that focuses on content and skills (quantitative, laboratory, etc.) most higher institutions are expecting students to know" (Galileo, 2013). The concern most AP Biology teachers struggle with, as encountered myself and observed on college board discussion groups, is how to deliver content, incorporate lab skills, and connect all four big ideas with each practice given such limited classroom time (AP Biology Teacher Discussion Group, 2016). Additionally, teachers wish to redirect compartmentalized thinking and introduce hands on techniques and illustrative models that pair skill and content within reasonable class time.

By incorporating lab based biotechnology in the classroom and introducing, revisiting, and assessing comprehensive knowledge using the team based learning approach, students will be able to show "evidence of learning as a demonstrated understanding of underlying content, [by means of] illustrative examples, concept and content connections, and [meeting] learning objectives" through interactive and engaging study (college board/ap central 2012). Furthermore, by connecting "real life to the content being taught to get the emotional engagement that draws students to learning," students will be active participants in the learning process rather than content receivers and should show improvement in their overall learning success.

Intervention

To reduce compartmentalized thinking and optimize content connections, my 2016-2017 AP Biology students will be assessed based on the average percentage of each individual's previous knowledge and an average percentage of team based knowledge using the TBL approach. Additionally, this 22 student population will perform the biotechnology driven lab, "Mutation and osmolarity of C. elegans" (Choe, 2015) and relate it to how mutations as learned within the central dogma of DNA, change the overall structure and function of proteins by means of the hands on activity "From DNA to protein structure and function" (Bokor et. al., 2013). To coordinate with the redesign of the new College AP Standards, the collaborative TBL method will be surveyed by students at the end of each unit to determine whether the student population were more confident in their understanding of content as well as the application of lab based parallels. Lastly, the average performance of unit tests of this current year's AP Students using the above mentioned strategies and biomedical labs will be compared to the overall average performance of unit tests of past AP Bio students within the past two years who have not been exposed to these methods. All students have or will have taken the revised form of the 2013 AP test so the standards and objectives remain the same.

Anticipated Connections to Bench to Bedside Summer Institute:

After completion of student inquiry of determining the molarity of 5 unknown solutions and recording the tonicity of plant cells with response to the correctly identified hypertonic, isotonic, and hypotonic solutions, students will be introduced to the wild type and mutant DPY-7 type of C. elegans. Additionally, students will correlate the physiological responses of C. elegans in normal and extreme environments to their previous inquiry of cell response to solution concentrations. Furthermore, students will further investigate, using the Pompe Predicament

lesson, “From DNA to protein structure and function” by modeling protein 3 dimensional structures and the changes in shape due to DNA mutations. Students will be using this “illustrative example” with the science take out kit. The OER Commons website will be used to show a short video clip of the central dogma and the result of single nucleotide mutations and how a particular mutation causes changes in the response and behavior of human populations in Africa.

Data Collection and Analysis:

Students will be given pre and post-evauations of their knowledge of content and skills before and after delivery of instruction, TBL strategy, and biotechnology skill based labs. Mean test scores of upcoming AP Bio students will be compared to previous AP Bio unit mean scores and chi square calculations will be conducted. The calculations will be represented on a liner graph to provide visual results of progress of overall conceptual understandings of the 4 Big Ideas of AP Biology. Student surveys regarding the TBL method will be averaged to determine whether students, as a whole population, considered this approach to be affective to understanding and connecting content within the 4 Big Ideas.

References

"AP Biology: Curriculum Framework 2012-2013," College Board inspiring minds. Web. 22 June 2016.

AP Biology Teachers' Discussion Group. "Biology: Handling Block Schedules and Heavy Teaching Loads," AP Central, 2001- present. Web. 22 June 2016

"Best Practices in implementing the High Schools That Work (HSTW), Making Grades Work (MMGW) and Technology Centers That Work (TCTW)," HSTW Staff Development Conference in New Orleans, summer 2012. Web. 22 June 2016

Bokor, Julie, et. al. *The Pompe Predicament*: adapted from the Science Take-Out Kit: From DNA to Protein Structure and Function. Gainesville: U of Florida, 2013. Web. 22 June 2016

Choe, K. P. "Introduction to C. elegans life cycle, anatomy, and behavior." Developed by the Choe Lab at the University of Florida. 2015.

Choe, K. P. "Mutation and osmolarity in C. elegans." Developed by the Choe Lab at the University of Florida. 2015.

College Board. "AP Biology Exam Data 2013," Galileo Academy, 2013. Web. 22 June 2016.

Lesson Plan

Title: "The Ins and Outs of Mutations, from the macro level to micro level!"

Key Questions:

1. How does the process of evolution drive the diversity and unity of life of a wild type and mutant type nematode, C. elegans, at the macro level and micro level?
2. How does the wild type and mutant type of the nematode utilize free energy and what molecular building blocks are involved to allow it to grow, reproduce, and maintain homeostasis?
3. How does the wild type and mutant type of nematode store, retrieve, transmit and respond to information essential to its life processes?
4. How does the wild type and mutant type of nematode systems interact and what complex properties at the molecular level do these systems possess?

Science Subject: AP Biology

Grade and Ability Level: Advanced Placement 11^{th}-12^{th} grade students with a background in biology and chemistry possess good math and writing skills.

Science Concepts:

- Prior knowledge of cell transport across permeable membrane. (Diffusion/Osmosis).
- Hypertonic, Hypotonic, Isotonic Solutions and outcomes of cells in those environments.
- Basic anatomy of C. elegans.
- Basic behaviors of nematodes on nutrient agar plates for both the wild type and mutant.
- Background knowledge of collagen as a protein and its role and function.
- Understanding of the central dogma: DNA-RNA-Protein and SNP's causing mutations.

- Mutations in DNA sequences cause a change in form of the protein resulting in a change in function.

Overall Time Estimate: Four 50-minute periods

Learning Styles: Visual, Auditory, Kinesthetic, Social, Solitary, Verbal

Vocabulary: mutation: is a genetic change that causes new and different characteristics.

Protein synthesis: the process in forming proteins from the DNA sequence.

Enzyme: A protein that affects the rate of a reaction and is essential in metabolic functions.

Protein structure: The 1,2,3 dimensional shape of bonded amino acids that have a specific function in cellular processes.

Lesson Summary: Over the course of four days, students will apply their knowledge from previous inquiry of tonicity of solutions and the effects on plant cells to the effects on a wild type and mutant type of multicellular worm, C. elegans. An IRAT will be conducted then a TRAT on the basic understanding of nematodes, mutant vs. wild type, and mutation in a gene sequence to protein structure will be assessed. Students will then perform Experiment 1 and 2 of Dr. Choe's C. elegans lab. Students will then utilize the take out science kit: "From DNA to Protein Structure and Function." Students, in groups, will then perform a web activity connecting the response of mutant worms to their hypertonic/hypotonic/isotonic environments as a result of SNPs in their gene sequence and a change in their physiological structure.

St**udent Learning AP Biology College Board Enduring Understandings and Objectives:**

From Big Idea 1

Enduring Understanding 1.A: Change in the genetic makeup of a population over time is evolution.

LO 1.2 The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution.

LO 1.5 The student is able to connect evolutionary changes in a population over time to a change in the environment.

Enduring Understanding 1.C: Life continues to evolve within a core changing environment.

LO 1.25 The Student is able to describe a model (using their C. elegans observations) that represents an evolving population.

From Big Idea 2:

Enduring Understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.

L.O 2.10 The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure.

L.O 2.11 The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function.

L.O 2.25 The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments.

From Big Idea 3:

Enduring understanding 3.A: Heritable information provides for continuity of life.

L.O 3.4 The student is able to describe representations and models illustrating how genetic information is translated into polypeptides.

L. O 3.6 The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression.

Enduring understanding 4.A: Interactions within biological systems lead to complex properties

L.O 4.3 The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.

L.O 4.7 the student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.

Materials: (Four each pair of students)

Mutant DPY-7 (e88) C. elegans
N2 wild type C. elegans
Plates with 350nM NaCl and OP50 bacteria
1 wire pick
1 dissecting microscope
1 small metal spatula
A sharpie marker
Copies of Experiment 1 and Experiment 2 of C. elegans by the Choe Lab U of F
Pencil and pipe cleaner
Copies of Science Take-Out: From DNA to Protein Structure and Function p. 54-57 from *The Pompe Predicament* Booklet
Science Take-out kit: From DNA to Protein Structure and Function

Background information:

Please view background content from inquiry lab regarding osmoregulation of various plant roots/fruits to newly discovered %M sucrose from Investigation 4 Diffusion and Osmosis based on the scientific question: “what causes plants to wilt if they are not watered?” (S-51-S60).

Please view background information from experiments 1 and 2 of C. elegans developed by Dr. Chou at the University of Florida.

Please view PowerPoint information provided by Dr. Chou as a resource from Bench to Bedside.

1. Students will have already preformed inquiry lab of determining molarities of a range of 0M to 2M sucrose solutions using dialysis bags and how this example relates to osmoregulation of living systems.
2. Students will have determined molarity changes in plant cells by coring, immersing, and timing the rate at which their core samples change in mass within each solution type.
3. Students will have the essential understanding of cell membrane permeability and the diffusion of solutes and water across areas of high and low concentrations.
4. Additional background information will include a brief video on C. elegans and discussion and model of its life cycle as well as an overview of the anatomical features of the worm including its collagen rich cuticle.
5. Again, students will revisit the experiments 1 and 2 of C. elegans and recall physiological conditions that differ from the wild type to the mutant type.
6. Students will have been probed as to what level of complexity in the body caused a change in the lack of molting in the Nematode as introduced in Lab #2.

7. Students will recall what collagen is made of (a **protein**) and how the look of the worm's cuticle is thicker in DPY-7 than of the wild type.
8. Students will also recall how the physiological changes in DPY-7 have allowed the worm to maintain homeostasis in a saltier environment versus normal conditions in the plate.
9. Students will have also recognized that the DPY-7 **mutant** sustains hypertonic environments vs. the wild type concluding that natural selection allows for more DPY-7 to survive and the population of DPY-7 will have evolved in greater population percentages over the wild types.
10. After viewing the video, From DNA to Protein (Nova Series), students will have reviewed essential vocabulary for **DNA→RNA→Protein** and will have modeled transcription and translation.
11. Students will then actively participate in the Take Home Science Kit: From DNA to protein form and function and simulate DNA (**central dogma**) sequences to correct **primary, secondary, tertiary, quaternary protein structure**.

Advance preparation:

- The teacher will need to order mutant and wild type C. elegans (enough for 112 students or 56 pairs of students).
- 2 plate for each pair with 350 mM and OP50 bacteria (contact Dr. Chou for specs and/or supplies)
- Check and set-up dissecting scopes
- Make copies of experiment 1 and 2 of C. elegans experiments provided by Dr. Chou (B2B 2016).
- Test PowerPoint slides of Nematodes.

- Check for access Protein Transcription/Translation Video
- Check out Take-out Kits on Protein Form and Function from UF Bench to Bedside.

Procedure and discussion questions with time estimates:

Day 1: Pretest: 5 questions regarding C. elegans (7 minutes)

Introduce Dr. Chou PowerPoint: C. elegans lifestyle cycle, anatomy, behavior (10 min)

Perform experiment (see experiment #1 handout) (30 minutes)

Day 2: Introduce Dr. Chou PowerPoint: Mutation of the DPY-7 vs. Wild type and its impact on collagen. (10 minutes)

Perform experiment (see experiment #2 handout) (30 minutes).

Posttest: 5 questions regarding C. elegans (5 minutes)

Later in the year, we have reached genetics and transcription/translation and protein form and function)

Day 3: Warm-up: Students will have modeled "pencil transferase" a (5 minute) activity as an inquiry of protein shape equates to protein function.

Implement Readiness Assurance Test using TBL strategies: (15 min)

IRAT: 5 questions (TBD)regarding how protein form and function relates to the earlier in the year experiments of the mutant C. elegans relates to its physiological structure. (7 min.)

TRAT: same 5 questions (TBD) are collaboratively discussed with teams of 4 and they justify/explain their rationale.

Application/Activity: DNA→Protein Kit by creating a (modified) model of a wild type and a mutant type protein to show proper and improper folding of proteins and therefore directly affect their structure.

Day 4:

Discussion of Protein Folding and Structure/Function results (10 minutes)

Assessment: Students answer AP level FRQ that ties in the 4 Big Idea Learning objectives to determine their understanding of content connections at the micro and macro level of gene to

organism and the biological effects on the organism based on one SNP mutation. (30 minutes).

Reflection H/W: TBL Survey as to whether the Team Based Learning Application to correlating the 4 Big Ideas was effective. (class averages will be taken and not an individual average).

Final Results:

Students are still learning and acquiring content on the above subject matter as the Central Dogma of life is our focus in 3rd quarter. As a result, statistical data is still in the collecting and analyzing phase. AP tests are not administered until May 2017 so comparisons of unit based knowledge acquisition and recollection are ongoing. Final results can be provided when student scores are released in July 2017.

Resources/References:

"AP Biology: Curriculum Framework 2012-2013," College Board inspiring minds. Web. 22 June 2016.

AP Biology Investigative Labs: An Inquiry-Based Approach. New York: College Board, 2012. Print.

Bokor, Julie, et. al. *The Pompe Predicament*: adapted from the Science Take-Out Kit: From DNA to Protein Structure/Function. Gainesville: U of F, 2013. Web. 22 June 2016

Choe, K. P. "Introduction to C. elegans life cycle, anatomy, and behavior." Developed by the Choe Lab at the University of Florida. 2015.

Choe, K. P. "Mutation and osmolarity in C. elegans." Developed by the Choe Lab at the University of Florida. 2015.

McCormack, Wayne. T. Ph.D. "TBL 101." Gainesville: U of F, 2016.