# FINAL REPORT, SPRING 2012

## Learning Biotechnology through the Study of Sickle Cell Anemia

Bench to Bedside, Summer 2011

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**Abstract:**

The purpose of this action research is to use an integrated approach to facilitate students' learning of biotechnology by focusing on a specific genetic disease. Sickle cell disease can focus on the basic biological concepts of genetics, protein biology, and biochemistry and can direct student learning by concentrating on a single condition. Biotechnology can be introduced as a mechanism of not only diagnosing the disease but also in the ability to offer viable treatment options if not now in the future. A variety of assessment tools can be used to guide the student through several text, internet, and hands-on laboratory experiences.

**Rationale:**

The purpose of this action research is to improve the understanding of the Central Dogma of biology (DNA-mRNA-Protein), the biology of proteins, the importance of amino acid sequence, and the diseases that can result. Through an integrated approach in teaching biology, biochemistry, pathophysiology, and biotechnology the high school anatomy student will gain a better understanding of basic biology concepts and relate these to relevant, real world examples that can be applied to other genetic diseases whether inherited or acquired in a lifetime.

Most people in this country lack the basic understanding of science that they need to make informed decisions about the many scientific issues affecting their lives (Singer, 2005). It is vital for science teachers from elementary to college to increase students' science literacy through active engagement in relevant laboratory experiences. Students often have a difficult time translating many of the important biological, physical, chemical concepts that occur in the natural world. In addition, it is often difficult for them to visualize how an understanding of the research in many of these concepts can assist in diagnosing and treating specific diseases and how biotechnology can be used in this process. Participation in a range of laboratory experiences holds the potential to enhance students' understanding of the dynamic relationship between empirical research and the scientific theories and concepts that both result from research and lead to further research questions (Singer, 2005). Through a specific focus of one genetic disease I hope to provide students the opportunity to learn, understand, and translate into action the scientific study of genetic diseases and how an understanding of basic science principles can facilitate biotechnological advances.

It is my belief that science literacy is important to every student regardless of future career endeavors. Most science education researchers believe that science education is intrinsically useful for students who do not go on to scientific or technical careers. A truly useful version of science literacy must be connected to the real uses of science in daily life; what is sometimes called public engagement with science (Feinstein, 2011). It should be the goal of science educators to reach every student through a

variety of text, activities, and laboratory exercises that will provide not only content knowledge but practical application with real world relevance.

There is a wealth of teaching and learning opportunities in science; traditional methods of text readings and accompanying worksheets have been used for decades (centuries?) to teach science topics of the time. According to Jose Vasquez in his article about the 1893 *Committee of Ten*, science education has had to change with the development of new knowledge and technology. The NEA in 1892 wished to deal with the issue of uniform college entrance requirements and made sweeping changes to science education of the time. Many of these recommendations hold true today, even with unimaginable science gains over the last 100 years. The general recommendations include:

- biology should precede chemistry and physics,
- the laboratory component was emphasized (greater than 60% of class time),
- physiology should be taught during the latter part of the high school years,
- students should make careful sketches/notes of observations,
- the primary purpose of the course was not on memorization but on the acquisition of knowledge and intellectual growth from careful observation of nature (Vazquez, 2006).

These recommendations made over one hundred years ago put to task the secondary science teacher to address the needs of the students and their knowledge of the natural world. Through a variety of teaching and assessment tools I hope to meet the needs of my student population and make them inquisitive, mindful observers of the world around them. The importance of biotechnology education is increasingly becoming a focus in the biology classroom; the problem is where to fit it in with an already overcrowded list of course objectives (Zeller, 1994). According to Zeller (referencing Dixon and Johnson, 1988) emphasized that the high school graduate should know that proteins construct living matter and are composed of amino acids according to a DNA code. This knowledge of proteins is then used in modern technologies to build products and processes based on molecular biology.

My focus will be on the anatomy & physiology student who should have a basic understanding/ recall of the Central Dogma of biology. Students are introduced to this concept in biology during the freshman or sophomore year however, not many biology teachers spend much time in teaching the USE of the translation process of DNA-protein in modern medical research or treatment of disease. My hope is to reintroduce the topics of genetics and protein synthesis and then layer the biotechnological concepts after this review to illustrate its importance. Through an extensive study of sickle cell disease we can incorporate all of the basic tenants of biology from genes, amino acid sequence, protein formation/folding, mutations, pedigree, and biotechnological methods for detection, diagnosis, and gene therapy.

**Action Research Intervention:**

The focus of the intervention will be all of my anatomy students; general anatomy, honors anatomy & physiology, and health science 1 (tech center bound). The intervention will be presented in an over-arching format that will include:

Attachment #1: Calendar of Lesson Integration; details of lessons below.

- Theme: *Sickle Cell Disease*
  - Lesson 1: Pathophysiology of disease and effects on human body
    - Objective: Describe the clinical symptoms of sickle cell disease, the resulting cell structure of the erythrocyte, and other body systems affected.
  - Lesson 2: Pedigree analysis of sickle cell disease
    - Objective: Describe the inheritance pattern of sickle cell disease and generate a pedigree to demonstrate inheritance.
  - Lesson 3: History and evolution of sickle cell disease
    - Objective: Understand the common belief that sickle cell trait was an evolutionary adaptation to protect populations from malaria infection.
  - Lesson 4: Normal vs. abnormal proteins
    - Objective: Describe and identify primary, secondary, tertiary, quaternary protein structures; active site exposure; denaturation; abnormal protein structure leads to abnormal protein function.
  - Lesson 5: Building blocks of proteins: amino acid sequence
    - Objective: Describe the structure of an amino acid; understand the differences between the 20 biologically active amino acids; demonstrate the importance of correct amino acid sequencing.
  - Lesson 6: Genetics of sickle cell disease/mutations
    - Objective: Identify the nucleotide bases found in DNA and RNA, illustrate the process of transcription and translation in the formation of abnormal and abnormal protein, identify the types of genetic mutations and the impact these mutations have on the transcription/translation process.
  - Lesson 7: Biotechnology: Detection and gene treatment of sickle cell disease
    - Objective: Understand the impact that biotechnology has on the diagnosis and treatment of sickle cell disease; identify other genetic diseases that can be diagnosed/treated through biotechnology.

**Connections to Bench to Bedside Summer Institute:**

- Theme: *Sickle Cell Disease*
  - Lesson 1: Pathophysiology of disease and effects on human body
    - Concept mapping of disease, symptoms, causes.
    - Rolando Milian: science database research
  - Lesson 2: Pedigree analysis of sickle cell disease
    - Pedigree for autosomal recessive genetic diseases.
  - Lesson 3: History and evolution of sickle cell disease
    - Drs. McKenna: Structural Biology
  - Lesson 4: Normal vs. abnormal proteins
    - Drs. McKenna: Structural Biology
  - Lesson 5: Building blocks of proteins: amino acid sequence
    - Drs. McKenna: Structural Biology
    - Learn genetics website, University of Utah
  - Lesson 6: Genetics of sickle cell disease/mutations
    - Pedigree practice
    - Dr. Wallace: Human genetics research
    - Dr. Baker: Molecular Genetics powerpoint
    - Learn genetics website, University of Utah
  - Lesson 7: Biotechnology: Detection and gene treatment of sickle cell disease
    - Pipetting activity with State College of Florida faculty
    - Online research skills
    - Prezi online presentation instruction

**Data Collection and Analysis (Techniques/Student Assessment):**

- Qualitative: Student Evaluation: Biotechnology questions/misconceptions
  - Attachment #2A: Adapted from NC State University, College of Agriculture and Life Sciences: *Biotechnology: Answers to Common Questions.*
- Quantitative: Basic Biology pre-/post- assessment Central Dogma
  - Attachment #3: Central Dogma pre- and post- assessment
- Quantitative: Concept Map: Protein transcription and translation
  - Attachment #4: Concept Map
- Quantitative: Pedigree Quiz
  - Attachment #5
- Qualitative: Pipette skills practical
  - Did not utilize
- Qualitative and Quantitative: Research skills and content of research poster
  - How to use Prezi lesson; not a poster presentation
- Qualitative: Student Evaluation on Biotechnology
  - Attachment #2B

**Literature Cited:**

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**Budget/Budget Justification:**

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| Print research posters @ $8.00 each | $ 40.00 |
| Reagents of Protein Crystallization | $125.00 |

**Permission:**

No special permissions needed.