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**CONCEPTION OF SICKLE CELL DISEASE IN TWO SELECTED SENIOR
HIGH SCHOOLS IN THE ADENTAN MUNICIPALITY**

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DECLARATION

CANDIDATE'S DECLARATION

I, ESTHER NUERTEY, hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been acknowledged, is entirely my own original work and has not been submitted for an award anywhere for another degree.

.....

Candidate's Signature

.....

Date

SUPERVISOR'S DECLARATION

I declare that the preparation of the dissertation was supervised by me in accordance with the guide lines on supervision of dissertation laid down by the School of Graduate Studies, University of Education, Winneba.

.....

DR. YAW AMEYAW

.....

Date

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DEDICATION

I dedicate this work to my beloved daughter, Nhyira Adomaa Odoi, my sons Nartey Kofi Odoi-Darko and Esmart Kweku Odoi- Darko, my husband Martin Odoi-Darko for the sacrifices made to help me achieve this height of academic laurel.



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ABSTRACT

The purpose of this study is to investigate Senior High School students' conception of the sickle cell disease (SCD). The study was conducted in two schools from the Adentan Municipality in the Greater Accra Region of Ghana. The total population of sample consisting of four hundred and twenty (420) was selected from two different Senior High Schools from one and two students. The accessible population included ninety-six (96) from Delcam and Two hundred and thirty-five (235) students from West Africa SHS's respectively. Twenty one instrument questionnaires were used to collect data. The data obtained from the survey were analysed with frequency counts and simple percentages using Statistical Package for Social Sciences (SPSS) version 17-2014 to validate the internal consistency with an Alpha Cronbach's value of 0.991. The results gathered showed significant percentages of the population exhibiting misconceptions and alternative conceptions about the conceptual details of the Disease. The findings suggests that teachers must precede instruction by identifying students' conceptions, misconceptions and alternative conceptions to help students understand the concept being taught. Finally, teachers are again encouraged to endeavour to focus on the long-term retention of knowledge of scientific concepts than what is being tested for.

CHAPTER ONE

INTRODUCTION

Overview

This chapter consists of the background of the study, the statement of the problem, the purpose of the study, the research questions (questions that guided the study), the educational significance and the limitation of the study.

Background of the study

According to Fisher and Wandersee (2001), research on student's conceptions have proliferated in the last twenty years and enhance our understanding about the preconceptions, misconceptions and alternative conceptions that students bring with them to the classroom. By now it is well accepted that alternative conceptions and misconceptions are common among students. These misconceptions are the major factors that impede students understanding of scientific concepts treated in the classrooms. Misconceptions are what students themselves develop erroneously, and are different from scientifically accepted concept (Kose, 2008). That is why it is necessary to determine the misconceptions that students already have.

According to the conceptual change theory, students' conceptual change can be facilitated by creating certain conducive conditions in the classroom. These includes; providing experiences that cause students to be dissatisfied with their current conceptions; spending time identifying students misconceptions and the most likely barriers to their forming new conceptions; implementing strategies that help students overcome their misconceptions;

presenting content in a variety of ways; and using forms of evaluations that allow the teacher to measure students' progress toward achieving conceptual change (Posner, Strike, Hewson, & Gertzog, 1982). When students are found to hold misconceptions, the teacher must determine which experiences will be most effective in getting students to change the way they think and thus to construct scientifically sound idea.

According to Gedik, Entepinar and Geban (2002), the teacher should be a guide that tries to understand the students' construction of knowledge and some cases of facilitating the learning process by asking effective questions, and additionally supporting them by guiding students to the right sources. In this learning process, information to be learnt should be arranged one by one to create groups of interrelated information. However, students have some previous knowledge before coming to the educational environment. This previous knowledge prevent the student from reaching scientifically proved information, and as a result of this, it becomes difficult or even impossible for students to acquire new information (Novak & Godwin, 1984).

Similarly, the conceptual change Approach, which is based on constructive learning theory, has frequently been used recently. It considers student previous knowledge and then all instructional activities are determined with respect to those considerations. Group work and demonstrative experiments have an important place in conceptual change approach. The first way to deal with students' misconceptions is to be aware of them. Teachers must be aware of student's prior knowledge and possible misconceptions.

During preparation of class topics and content, teaching methods that are suitable for reducing misconceptions should be chosen. In the case of demonstrative experiments based on conceptual change, students become aware of their existing misconceptions and these misconceptions are revealed through questions and demonstrations, and discussions to

enable students to realise scientific facts and combine them with their prior knowledge. Therefore, demonstrative experiments based on conceptual change are an effective method to reduce and prevent students' misconceptions (Gedik, Ertepinar & Geban, 2002). Moreover, group work based on the conceptual change approach that centralises on students and makes them the explorer and constructor of knowledge to improve their understanding is necessary to simplify the teaching of concepts (Cayci, Demir, Basran & Demir, 2007). The best way to understand a subject in science and technology education is to work on the subject and make connections with other science fields (Turgut, Baker, Cunningham & Piburn, 1997).

Therefore, science and technology education should accomplish integrity with other fields like physics, chemistry and biology. Especially for biology, connections and integrity of concepts have an important role in science and technology education. Consequently students have a few problems in learning concepts meaningfully, and they prefer to memorize those concepts. The most evident example of this can be seen in areas of genetics.

In other studies a number of workers have, however, highlighted several factors that contributes to the difficulty and limited genetics education of health care (Guttmacher, Porteous & McNemey, 2007). These factors include crowded curricula; lack of knowledgeable faculty; genetics content that is not presented in a way that leads to long-term knowledge retention; failure to incorporate genetics into clinical training, inadequate representation of genetics on certifying exams; lack of evidence-based guide lines in genetics; and misconceptions that genetic medicine is defined by rare, Mendelian disorders, when in fact genetics is increasingly concerned with the common, chronic diseases that are the daily focus for most health, professionals.

Misconceptions are formed through five categories: oversimplifications, overgeneralizations, obsolete concepts or terms, misidentifications, and flawed research (Hershey, 2004). Many pre-service biology teachers in most countries are ill prepared to teach genetics, and therefore cannot readily recognise errors in literature and textbooks. Students' misconceptions are reinforced due to ignorance. Hersey, (2004) suggested that Biology teachers must however focus on these misconceptions in order to identify substandard literature being used by students.

Overcoming misconceptions is crucial to students' learning. When misconceptions are challenged directly and students are provided with opportunities to re-construct their world view, the proportion of students that are able to use science conceptions to explain phenomena increases significantly (Fisher & Wandersee, 2001). Many studies in science education have focused on students' misconceptions in the area of biology, especially those related to genetics. Sickle Cell Disease (SCD) is a significant public health burden in Ghana. Recent studies indicate that 2% of Ghanaian new borns are affected by SCD; one in three Ghanaians has the haemoglobin S and/ or C gene and carrier rate of 30% of HbS or C (Ohene-Frimpong, 2010). Recommendations are made from three levels for controlling the Sickle Cell Disease. These includes; preconception genetic testing and strategic reproductive choices, Prenatal Diagnosis (PND) and Education for carrier parents, and holistic management of persons with SCD. The studies also emphasised on the critical importance of self-management, especially self-awareness, in assuming a good quality of life for persons with SCD. They believe such an approach is cost-effective, and consistent with sound ethical principles and good conscience. Similarly, studies conducted by the World Health Organization (WHO) indicated that, 5.2% of the World's population and over 7% of pregnant women carry an abnormal haemoglobin gene which is quiet alarming and therefore, they must be given the needed attention through a meaningful learning of

the concept. In other related studies in the United States, about 1 in 500 African-Americans develop sickle cell anaemia and in Africa about 1 in 100 individuals develop the disease (Chowing, 2000). The researcher further sought to answer the question why is the frequency of a potentially fatal disease so much higher in Africa? The answer is related to potentially fatal disease malaria. The disease is prevalent in Africa because the vector *Anopheles* mosquito is a protozoan parasite prevalent dominant in the sub-Saharan region.

When malarial parasites invade the blood stream, the red cells that contain defective haemoglobin become sickled and die, trapping the parasites inside them and reducing infection. Compared to AS heterozygous, people with the AA genotype (normal haemoglobin) have a greater risk of dying from malaria. Death of AA homozygotes results in removal of alleles from the gene pool. Individuals with the AS genotype do not develop sickle cell anaemia and have less chance of contracting malaria. They are able to survive and reproduce in malaria-infected regions. Therefore, the A and S alleles remain in the population. SS homozygotes have sickle cell anaemia which usually results in early death. In this way, S alleles are removed from the gene pool. In a region where malaria is prevalent, the S allele confers a survival advantage on people who have one copy of the allele, and the otherwise harmful S allele is therefore maintained in the population at a relatively high frequency. Current research indicates that the oxygen requirements of a foetus differ from those of an adult, and so perhaps not surprisingly, prenatal blood contains special haemoglobin. With these discoveries; understanding how this genetic switch works could allow researchers or biology students to understand much about the control of genes in general and Sickle Cell Disease in particular. In another research, mice that have been genetically engineered to contain a defective human B globin which exhibited symptoms typical of sickle cell anaemia were mated to another transgenic mouse line expressing human foetal haemoglobin. When compared to their sickle cell parents, the

produced offspring have greatly reduced numbers of abnormal and sickle RBC's overall (Reduced anaemia), and longer life spans (Karlsson, 2000). The experiment established that only 9-16% of haemoglobin need be the foetal type in order to ameliorate sickle cell symptoms, and are an important first step in a gene therapy solution to sickle cell disease. Even though this research has invalidated some conceptions of the sickle cell disease, some students still hold the misconception that once you have the disease, you cannot grow to get to adulthood stage of life.

Research reveals that misconceptions about scientific concepts are hard to eliminate through traditional approaches because it is a permanent and continuous process (Tekkaya, Capa & Yelmaz, 2000).

Cepni, Tas, and Kose, (2006) carried out a study to reveal the cognitive development, misconceptions and attitudes of students about the genetic concept. They concluded that, making use of computer assisted Instruction Material (CAIM) was very crucial for attaining the application and comprehension levels of cognition in teaching genetics. However, they observed that CAIM did not substantially change the misconceptions of students about genetics.

Studies by Cho, Kahle and Nordland (1985) revealed that difficulties that students face in learning genetics comes from the high school biology textbooks they use. They therefore concluded that some of these books are sources of misconceptions.

Similarly, a study exploring Taiwanese high school (11th grade and 12th grade) students' conceptions of learning science through a phenomenographic analysis, was undertaken on the basis of the following five rationales (Boulton-Lewis, Wilss & Lewis, 2001).

Research has revealed that the conceptions of learning are related to learning approaches, which then influence the learning outcomes. For example, the study conducted by Purdie, Hattie and Douglas, (1996) showed that the Australian and Japanese secondary students having the conception of learning as „understanding“ tended to have better use of self-regulated learning strategies and quite different conceptions of learning; secondly, students „conceptions of learning are influenced by culture. According to Dart, Burnett, Purdie, Boulton, (2000) high school students in Australia who reported qualitative conceptions of learning (such as emphasizing understanding) tended to use deep approaches to learning, whereas students holding quantitative conceptions of learning (such as focusing on memorization) were likely to use surface approaches.

Research also suggested that deep approaches to learning were associated with better learning outcomes (Chin & Brown, 2000; Trigwell & Prosser, 1991). These findings strengthen the need for probing different conceptions of learning held by students, because they are related to students“ learning strategies and thus their outcomes.

Educators have asserted that using the phenomenographic method can explore conceptions that may be influenced by cultures, as it enhances the possibility of revealing some conceptions that are „endemic“ to the culture (Dahlin & Regmi, 1997).

Many recent studies about the conceptions of learning for a variety of cultural groups have used the phenomenographic method (Boulton-Lewis *et. al.*, 2001).

As the sample in this study included a group of high school students in Taiwan, who were educated in an Eastern culture, the phenomenographic method was utilized in this study.

The study conducted by Marton, Watkins and Tang, (1997) exploring high school students' conceptions of learning in Hong Kong also used the phenomenographic approach.

They also highlighted the importance of studying Asian (particularly Chinese-related) students' conceptions of learning, as there were seemingly paradoxical results between two stereotypes of „the brainy Asian“ and „the Asian learner as a rote learner“.

Thirdly, the conceptions of learning are related to educational contexts. The studies by Eklund-Myrskog (1997, 1998); Marshall, Summer and Woolnough (1999) supported this claim, and they found students with different majors or educational contexts, such as nursing, engineering or science, expressed quite different conceptions of learning.

As these studies examines the role of educational contexts or majors on students' conceptions of learning, they were usually conducted with higher education students who had a clearer focus on the field of learning. In Taiwan, high school students, from the beginning of the 11th grade, are required to choose a major either in the field of science or art and then they are educated with different types of curricula (Marton, *et.al.*, 1997).

Because the sample in this study consisted of Taiwanese 11th and 12th graders, it provided a particular opportunity to examine the role of educational contexts or curricular programs on the conceptions of learning. Therefore, one important feature of this study was the fact that it was a comparative study across two subject domains (science versus art) within the high school educational background of Taiwan. This part of the exploration may also expand the findings gathered from higher education students to younger learners (Tsai, 1998).

The conceptions of learning, to some extent are domain dependent; In other words, an individual student may have different conceptions toward different domains of learning (e.g. science versus history). The review by Buehl and Alexander (2001), and studies also by Lonka, Joram & Bryson, (1996) as well as Prosser *et al.* (1996) shared this view.

Buehl and Alexander (2001) called these conceptions as domain-specific epistemological beliefs. This study further differentiated the domain-specific epistemological beliefs as academic domain-specific epistemological beliefs. The results of the study viewed conceptions of learning as academic (school) epistemological beliefs, representing student beliefs about school knowledge and learning. However, these conceptions or beliefs are probably related to domain-specific epistemologies. For example, students may have quite different views about the nature of science and the nature of history, and then guide them to different conceptions about learning science and history. That is, students' views about the nature of the knowledge domain still play a role in their conceptions of learning toward the specific domain of knowledge.

Research in science education exploring students' views about the nature of science also has suggested that students' epistemological beliefs about science are related to their approaches to learning science (Lederman, 1992; Tsai, 1998).

Finally, many studies have focused on college students (for example, Boulton-Lewis *et al.*, 2001, Marshall *et al.*, 1999), with only a few exceptions on high school students (Marton, Watkins & Tang, 1997).

This type of research should not be limited to higher education, as younger students have already developed their conceptions of learning (or learning science). A careful investigation about relatively young students' conceptions of learning can provide more

insights for the existing research literature. Hence, this study chose high school students as the target subjects for the research.

Statement of the problem

Sickle Cell Disease is a group of disorders that affects haemoglobin, the molecule in red blood cells that delivers oxygen to cells throughout the body. The disease is a potentially deadly genetic disease, which can be transferred from two parents having the sickle cell trait in their red blood cells to their offspring's. Science students of West Africa and Delcam Senior High Schools have several misconceptions about the Sickle Cell Disease. For example some students perceived that, the disease affects only people of black origin; others do not understand the genetic principles of the disease. Again most students do not know that the Disease can be treated in ones infancy upon early diagnoses. The concept is however, an aspect of the Senior High School (SHS) Biology syllabus and some other science fields in tertiary institutions in Ghana, students are not able to grasp the concept meaningfully, and being a prerequisite for genetics in the tertiary level, inability of students to comprehend the basic principle would create more difficulties to grasp the concept in higher levels. The study therefore seeks to find out SHS students conception about sickle cell Disease, and subsequently suggest appropriate solutions for a meaningful learning of the concept.

Purpose of the Study

The main purpose of this study was to identify SHS student's conceptions of sickle cell disease. It is the researchers' desire to assess students' knowledge on sickle cell disease with focus on mode of transmission, myths and general conceptualisation of the disease to inform teaching and learning about this important genetic disease in Ghana.

Research Questions

In order to substantiate the facts about students' conceptions on sickle cell disease. The following research questions guided the study:

1. What are the conceptions of students about sickle cell disease as a concept?
2. Does their society influence these conceptions?
3. Are these conceptions based on scientific proves?
4. What can educators do to clear possible misconceptions in students' minds?
5. Are these misconceptions motivated by societal, cultural and ethical beliefs?

Significance of the study

Results obtained from the studies would enhance curriculum development. Secondly, misconceptions that impede students' understanding of the concept would be addressed specifically and this would directly and indirectly improve public education of the sickle cell disease to prevent or minimize its menace from affecting more lives in families and the society as a whole. It would also guide students to make informed decisions regarding their marital lives and those of others.

Finally, recommendations made after the findings could be adapted by Biology teachers in the municipal area to augment students' misconceptions to those that are scientifically proven.

Limitation

Ideally, the study should have been conducted in all Senior High Schools in the Adentan municipality of the Greater Accra Region of Ghana. However, due to financial constraints

and the fact that the research was time bound, the researcher limited herself to two schools in the municipality.



CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter focuses on the review of ideas, facts and thoughts expressed by some authorities in relation to the topics under study. The literature is reviewed under the following sub-topics:

- Student's conception of Genetics.
- Ethical, Religious and Societal conceptions of SCD.
- The concept of Sickle Cell Disease as a Scientific Concept.
- Symptoms of Sickle Cell Disease.
- History of Prevalence of SCD in some Countries.

Students Conception of Genetics

For this particular study, the Multiplayer Educational Gaming Application (MEGA) created targeted genetics concepts, as such attention must be paid to some of the prior work that has looked at students' understandings of genetics. Despite its worldwide presence in secondary school science curricula, and its critical importance in modern biomedical sciences, agriculture, forensics, and the pharmaceutical industry, genetics remains conceptually and linguistically difficult to teach and learn (Tsui & Treagust, 2007). Generally speaking, the prior research focusing on students' understandings of core

genetics concepts (e.g. DNA, RNA, gene, chromosome, protein, DNA replication, transcription, translation, and Mendelian inheritance) suggest that the simultaneous exposure to objects and processes at the macro and molecular levels of organization and the scarcity of direct concrete experiences with these ideas has made their learning difficult, at best (Bahar *et al.*, 1999; Hackling & Treagust, 1984).

While several researchers for example Peebles and Leonard, (1987) and Tsui & Treagust, (2007) point to improved understandings due to the use of models (both physical and computer-based), the development of robust concepts of and efficient problem solving in genetics continues to be a struggle for most children. These conceptual difficulties also help build a case for the importance of this current study.

Bahar, *et al.*, (1999) used the word association test which is known to be one of the commonest and oldest educational tools for investigating the cognitive structure of learners. In this present study, a word association test was used to map the cognitive structure of areas of elementary genetics in first-year biology students. In order to map the structures, relatedness coefficient values and response frequencies were used. The results showed that the students generated many ideas related to given key words. However, they did not appear to see the overall picture as a network of related ideas. Implications for using the word association test in the classroom are discussed.

In a related study, scientist have discovered that the improvement of meaningful understanding of scientific concepts has long been a central goal of science education. To achieve this goal, learners must be actively engaged in meaningful learning, seek to relate new concepts to prior knowledge, and use their new conceptual understanding to explain experiences they encounter (Ausubel, 1963; Novak, 2002). According to Ausubel, meaningful learning occurs when students consciously link new knowledge to relevant

concepts they already possess. Otherwise, rote learning occurs. In rote learning, students do not integrate new concepts to their prior knowledge to form a coherent framework. As a result, they tend to rely on memorizing isolated facts (Novak, 2002). Researchers claim that students who frequently use rote learning tend to generate misconceptions concerning scientific concepts (BouJaoude, 1992). Genetics is among such topics. Although genetics requires the ability to meaningfully relate different concepts in life science, researchers have shown that it is generally learned by rote (Stewart, 1982).

Genetics is considered one of the most important and difficult topics in the school science curriculum (Bahar, Johnstone, & Hansell, 1999; Tsui & Treagust, 2004). Researchers have reported several reasons why genetics concepts are difficult for students to learn. For example, Knippels, Waarlo, and Boersma (2005) indicated that these difficulties originate mainly from the domain-specific vocabulary and terminology, the mathematical content of Mendelian genetics, the cytological processes, the complex nature of genetics, and the abstract nature of the subject matter. According to Baker and Lawson (2001), various genetics concepts such as Sickle Cell Disease depend on imaginary (theoretical) ideas constructed in abstract hypothetic deductive conceptual systems. Therefore, sound understanding of theoretical genetics concepts requires learners to reason hypothetico-deductively. Likewise, Banet and Ayuso (2000) argued that meaningful understanding of genetics is difficult and requires a certain level of abstract thought. They also criticized the traditional teaching approach and suggested the development of more effective alternatives. Smith and Sims (1992) analysed the research on the nature of the relation between formal operational thought and genetics problem solving. Those authors stressed the availability of instructional techniques that could facilitate comprehension of genetics. The learning cycle is one of the teaching strategies that can promote this effort (Cavallo, 1996; Marek & Cavallo, 1997; Smith & Sims, 1992).

The learning cycle, derived from Piaget's (1950) model of mental functioning, was introduced as part of the Science Curriculum Improvement Study to enhance elementary school students' concept development and to enhance the introduction of formal concepts (Karplus, 1977). The learning cycle is an inquiry-based teaching strategy that divides the instruction into three phases: exploration, concept introduction, and concept application (Karplus, Purser & Renner, 1983). During exploration, for example, the teacher provides learners with concrete experiences related to the content to be learned. This phase allows students to mentally examine ideas via brainstorming to identify what they already know. After exploration, the teacher introduces the concepts to the learners more explicitly. The teacher promotes a discussion period in which students share their observations with their peers. The teacher then links learner experiences to the relevant scientific concept. After the identification of scientific terminology, learners engage in additional activities in which they apply their newly developed knowledge to novel situations (Colburn & Clough, 1997). According to Abraham and Renner (1986), there is a direct correspondence among the elements of Piaget's mental function model and the phases of the learning cycle. For example, the exploration phase allows students to assimilate the essence of the science concept through direct experience. When students investigate a new concept through an exploration, their new experiences cause them to re-evaluate their past experiences. This process produces disequilibrium, and students need to integrate the concept to reach equilibration. The concept application phase provides students with opportunities to relate the newly developed science concept to everyday applications through a cognitive process that Piaget referred to as organization. This phase helps learners to mentally organize the new experiences by forming connections with previous experiences (Marek & Cavallo, 1997). The learning cycle makes students aware of their own reasoning by encouraging them to reflect on their previous activities. Researchers have claimed that once learners

become aware of their own reasoning and apply new knowledge successfully, they become more effective in searching for new patterns (Sunal & Sunal, 2003). In summary, the overall goal of the learning cycle is to help students construct new knowledge by creating conceptual change through interaction with the social and natural world. The inquiry teaching strategy takes into account students' developmental levels and helps them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and become aware of their own reasoning (Sunal & Sunal, 2003).

Since its introduction, the learning cycle has been the focus of various studies in the field of science education. In many of these studies, researchers have documented the effectiveness of the learning cycle and demonstrated that this approach has widespread applicability to a variety of grade levels and disciplines (Colburn & Clough, 1997; Marek & Cavallo, 1997). Results of these studies have revealed that instruction based on the learning cycle enhanced not only conceptual understanding but also process-skill achievement. For example, Renner (1986) tested the effectiveness of the learning cycle versus expository instruction in promoting gains in content achievement and intellectual development of 9th- and 10th grade students. Results showed that learners at the concrete level taught by the learning cycle method made significantly greater gains on concrete concepts and moved more often from one developmental level to another in comparison with students in the expository group. Purser and Renner (1983) and Schneider and Renner (1980) have reported similar findings. Working with 6th graders, Saunders and Shepardson (1987) investigated the effects of concrete (learning cycle) and formal (traditional) instruction on reasoning and science achievement. They reported statistically significant higher levels of performance in science achievement and cognitive development favouring the learning cycle instruction group and a statistically significant gender effect favouring boys. Likewise, Marek, Cowan, and Cavallo (1994) reported that learning cycle instruction

was more effective than expository instruction in promoting high school students' understanding of genetics. In another study, Barman *et al.* (1996) compared the learning cycle teaching approach with a textbook or demonstration method of instruction to determine whether one method was more effective in facilitating 5th-grade students' conceptual change concerning Sickle Cell Disease. The findings indicated that students who were taught by the learning cycle had a significantly better understanding. Balci, Cakiroglu, and Tekkaya (2006) found significant differences among the learning cycle and traditional groups in favour of the learning cycle with respect to students' understanding of Sickle Cell Disease in human.

In addition to research supporting the effectiveness of the learning cycle in facilitating a better understanding of scientific concepts, several other studies have focused on identifying the variables that affect students' achievement. Although, in some of these studies, researchers have investigated the role of cognitive variables on science achievement (BouJaoude, 1992; Cavallo, 1996), others have taken both motivational and cognitive variables into account (Cavallo, Rozman, Blickenstaff & Walker, 2003). These researchers generally used reasoning ability, learning approach, and prior knowledge as cognitive variables and self-efficacy, motivational goal, and failure tolerance as motivational variables. Much of the research, however, has focused on the cognitive aspects of teaching and learning science. Among them, reasoning ability has received the most attention from researchers. In previous studies, many researchers have consistently reported that the ability to reason formally is the strongest predictor of meaningful understanding of scientific concepts, including genetics. Lawson and Thompson mentioned that high-formal students who no longer require concrete objects to make rational judgments and are capable of hypothetical and deductive reasoning, performed better than low-formal students. High-formal students are able to understand both concrete and formal

concepts. They have developed sound understanding of abstract concepts. Such students are capable of looking for relations, generating and testing alternative solutions to problems, and drawing conclusions by applying rules and principles. Low formal students are concrete reasoners, who are unable to develop sound understanding of abstract concepts. They are able to understand only concrete concepts. Low-formal students have not fully developed formal thought yet. Those researchers tested the hypothesis that formal reasoning ability is essential for 7th-grade students to successfully deal with misconceptions and develop scientifically acceptable conceptions of genetics and natural selection following standard lecture-textbook-based instruction. The researchers found that the number of misconceptions is consistently, statistically, and significantly related to reasoning ability. In an earlier study, Lawson and Renner (1975) reported that interpreting and solving genetics problems requires formal-level operations such as probabilistic, combinational, and proportional reasoning that is in line with Piaget's developmental theory. Researchers have also suggested meaningful learning orientation as a main predictor of students' science achievement. Cavallo and Schafer (1994) defined learning orientation as the extent to which learners use meaningful or rote approaches to learning new information. Students with a meaningful learning orientation try to make connections among concepts, whereas students who do not possess a meaningful learning orientation concentrate on memorizing ideas, concepts, and facts. In their study, Cavallo and Schafer explored the relation between students' meaningful learning orientation and their understanding of genetics topics. They found that meaningful learning orientation and prior knowledge of meiosis were significant predictors of students' meaningful understanding of meiosis. In another study, Cavallo (1996) explored the relations among students' meaningful learning orientation, reasoning ability, and acquisition of genetics topics. She reported that, meaningful learning orientation best predicted students' understanding of

genetics interrelations, whereas reasoning ability best predicted students' achievement in solving genetics problems. Cavallo concluded that students' use of meaningful learning was most important for understanding genetics concepts, whereas formal reasoning was most important for solving genetics problems.

Apart from reasoning ability and meaningful learning orientation, researchers have revealed that achieving meaningful understanding might also require relevant prior knowledge. For example, Haidar (1988) compared high school chemistry students' applied and theoretical knowledge of concepts on the basis of the particulate theory. He reported that students' formal reasoning ability and pre-existing knowledge played a significant role in their conceptions and use of the particulate theory. Likewise, BouJaoude and Giuliano (1994) demonstrated that prior knowledge, logical thinking ability, and meaningful learning orientation accounted for 32% of the variance in chemistry achievement. Johnson and Lawson (1998) extended the previous studies by examining the relative effects of reasoning ability and prior knowledge on biology achievement in relation to types of instruction. They found that reasoning ability- but not prior knowledge- explained a significant amount of variance in final examination scores in both instructional methods (expository and inquiry).

Researchers' attention has recently turned toward motivation because of evidence indicating that science teachers may have a more direct influence on their students' motivation than on cognition (Anderman & Young, 1994). For example, Cavallo *et al.* (2004) explored the relative predictive influences of learning approaches, motivational goals, self-efficacy, beliefs about the nature of science, and reasoning ability on physics concept understanding and course achievement among male and female students in an inquiry-based physics course. The regression analyses showed that although both self-

efficacy and reasoning ability best predicted female students' concept understanding, only self-efficacy positively predicted male students' physics understanding. More recently, Kang *et al.*, (2005) examined the relations among 7th-grade Korean students' cognitive and motivational variables, cognitive conflict, and conceptual change regarding density concepts. The cognitive variables were logical-thinking ability, field dependence or independence, and learning approach, whereas the motivational variables were failure tolerance, goal orientation, and self-efficacy. All cognitive variables and the motivational variables of failure tolerance and self-efficacy were significantly correlated with conceptual change. The results of stepwise multiple regression analysis showed that logical-thinking ability, field dependence or independence, and failure tolerance were statistically significant predictors of conception test scores. The researchers also reported that logical thinking-but not the meaningful learning approach-accounted for the greatest portion of the density conception test score variance in conceptual change classes.

In addition to the aforementioned variables, researchers have documented that science is one of the areas in which gender difference is most strongly pronounced. In those studies, however, researchers did not conclusively demonstrate findings on the relation between gender and science achievement. Although some researchers have indicated no significant difference between boys and girls with respect to science achievement (Dimitrov, 1999; Soyibo, 2004), others have reported significant gender differences (Alparslan, Tekkaya, & Geban, 2003; Cavallo *et al.*, 2004). For example, (Dimitrov, 1999) indicated no significant difference between girls and boys with respect to achievement in life sciences. Likewise, Soyibo (1999) reported no significant gender difference in Jamaican 8th-grade students' performance on nutrition and plant reproduction concepts. Soyibo, however, demonstrated that girls performed significantly better on a test of errors in biological labelling. In another study, Young and Fraser revealed significant gender differences in biology achievement in

favour of boys. Stark and Gray (1999) reported that girls performed at significantly higher levels on tasks in which the content and context were drawn from the biological sciences and on written tasks assessing science skills. However, those researchers found boys to be superior in the physical sciences. In an experimental study, Alparslan *et al.* (2003), explored gender differences in the relative effectiveness of two modes of treatment (conceptual change instruction and traditional instruction) on 11th-grade students' understanding of respiration. The authors reported a significant difference between girls' and boys' performance in favour of the girls, but they found the interaction of treatment with gender difference to be non-significant for learning the concepts. They concluded that the mean difference for one factor (gender) does not depend on the levels of the other factor (treatment).

Our review of the related literature provides background information concerning the relations among cognitive variables, motivational variables, and students' science achievement. In the available studies, researchers have tried to explore contributions of cognitive and motivational variables to college students' science achievement, mainly in inquiry-based science classes. However, comparative effects of these variables on elementary science achievement with different instructional strategies have not been well documented. For the present study, we chose genetics because of its curricular significance. It is a fundamental part of the science curriculum and is considered an abstract and difficult topic for both students and teachers. Although researchers in several studies discuss the difficulties of teaching and learning genetics, others focus on students' ideas related to genetics concepts. However, researchers have given less attention to developing strategies to eliminate these difficulties, remediate misconceptions, and improve genetics instruction in elementary science classes. To promote achievement in

elementary science classes, it is worthwhile to explore the influence of mode of instruction and motivational and cognitive variables on genetics achievement.

Ethical, Religious and Societal Conception of Sickle Cell Disease

Research work carried out by Brown (2011) confirmed that sickle cell disease is a timely issue that needs to continue to be a part of public discussion. Although sickle cell disease was discovered a little more than one hundred years ago, it has received only limited attention from the biomedical community. Sickle cell disease is often used in high school biology textbooks along with haemophilia as examples for instruction of introductory genetics, which should make it a widely known illness. However, sickle cell disease is often marginalized because the genetic nature of the illness could "mark" carriers and affected individuals. Also, structural inequalities within biomedicine and social inequalities in communities with a prevalence of the illness tend to direct resources away from sickle cell disease research and interventions in favour of other diseases. As the researcher has been describing this research project to people in the United States, He has encountered many whose understanding of the illness is limited to the brief statement "It's a black disease." This phrase is problematic for several reasons. For some people, "black" reflects awareness that the illness is prevalent among people with African ancestry, but they may not be aware that the illness also affects many other groups. For others to whom he has spoken with, the implication is that the disease affects "those people."

Although genetic diseases are not infectious, they must be studied meaningfully because they are genetically communicable; in the cases of diseases with harmful recessive traits, they are sometimes unknowingly perpetuated in children and other future generations. Understanding why a genetic disease appears more frequently among one group in a population requires several perspectives as Nigeria has the highest population of Sickle

Cell Anaemia (SCA) patients in the whole world. This condition manifests with frequent episodes of aches and pains, recurrent infections, and frequent hospitalization. Prenatal screening is one of the methods of reducing the prevalence of this disease. In a related study by Adeola, Nwodo & Njokanma, 2012, they determined the awareness and acceptability of prenatal screening for SCA among health professionals and students at the Lagos University Teaching Hospital. A descriptive and cross-sectional study carried out between August and September 2006, involving 403 health professionals and students using structured questionnaires revealed that 91.3% of the respondents had heard about prenatal screening for SCA, whereas 8.7% of the respondents had not. In addition, the majority of the respondents (75.3%) knew that SCA can be prevented by prenatal screening for SCA, whereas 13.7% and 11.3% were not aware or not sure, respectively. Up to 48.2% of the respondents were not aware that prenatal screening for SCA is available in Nigeria with the nurses being the least aware. 42.1% of the respondents will not allow preventive termination of pregnancy if prenatal screening confirms SCA. For those who will not allow preventive termination, up to 79% of them decided on the basis of their religious beliefs. There is a poor level of awareness of the availability of prenatal screening services in Nigeria among health workers in Lagos, and religion is a major factor militating against its acceptability. Also, in Ghana findings from a study on the Sickle Cell Disease documented on a local radio station by Boateng in 2014 revealed that a section of the people in the northern part of the country believes that the diseases is a curse from the gods. These results in frequent stigmatization and discrimination meted out to people with SCD and this has led to a further sense of isolation from family and society. The stigmatization and discrimination associated with SCD is such that patients sometimes lose their accommodation. One young man and his family were ejected from their

accommodation when his landlord got to know that he has Sickle Cell Anaemia (Edwin, 2010). Thus the psychosocial burden of SCD is not insignificant.

The Concept of Sickle Cell Disease as a Scientific Concept

Sickle-cell disease (SCD), or sickle-cell anaemia (SCA) or drepanocytosis, is a hereditary blood disorder, characterized by red blood cells that assume an abnormal, rigid, sickle shape. Sickling decreases the cells' flexibility and results in a risk of various complications. The sickling occurs because of a mutation in the haemoglobin gene. Individuals with one copy of the defunct gene display both normal and abnormal haemoglobin. This is an example of codominance.

Life expectancy is shortened. In 1994, in the US, the average life expectancy of persons with this condition was estimated to be 42 years in males and 48 years in females (Platt *et al.*, 1994) but today, thanks to better management of the disease, patients can live into their 70s or beyond.

Sickle-cell disease occurs more commonly among people whose ancestors lived in tropical and sub-tropical sub-Saharan regions where malaria is or was common. Where malaria is common, carrying a single sickle-cell gene (sickle cell trait) confers fitness. Specifically, humans with one of the two alleles of sickle-cell disease show less severe symptoms when infected with malaria (Wellems *et al.*, 2009).

Sickle-cell anaemia is a form of sickle-cell disease in which there is homozygosity for the mutation that causes HbS. Sickle-cell anaemia is also referred to as "HbSS", "SS disease", "haemoglobin S" or permutations of those names. In heterozygous people, that is, those who have only one sickle gene and one normal adult haemoglobin gene, the condition is referred to as "HbAS" or "sickle cell trait". Other, rarer forms of sickle-cell disease are

compound heterozygous states in which the person has only one copy of the mutation that causes HbS and one copy of another abnormal haemoglobin allele. They include sickle-haemoglobin C disease (HbSC), sickle beta-plus-thalassaemia (HbS/ β^+) and sickle beta-zero-thalassaemia (HbS/ β^0).

The term disease is applied because the inherited abnormality causes a pathological condition that can lead to death and severe complications. Not all inherited variants of haemoglobin are detrimental, a concept known as genetic polymorphism.

Normally, humans have Haemoglobin A, which consists of two alpha and two beta chains, Haemoglobin A₂, which consists of two alpha and two delta chains and Haemoglobin F, consisting of two alpha and two gamma chains in their bodies. Of these, Haemoglobin A makes up around 96-97% of the normal haemoglobin in humans.

Sickle-cell gene mutation probably arose spontaneously in different geographic areas, as suggested by restriction endonuclease analysis. These variants are known as Cameroon, Senegal, Benin, Bantu and Saudi-Asian. Their clinical importance springs from the fact that some of them are associated with higher HbF levels, e.g., Senegal and Saudi-Asian variants, and tend to have milder disease (Green, Fabry, Kapute-Noche & Nagel, 1993).

In people, heterozygous for HgbS (carriers of sickling haemoglobin), the polymerisation problems are minor, because the normal allele is able to produce over 50% of the haemoglobin. In people homozygous for HgbS, the presence of long-chain polymers of HbS distort the shape of the red blood cell from a smooth doughnut-like shape to ragged and full of spikes, making it fragile and susceptible to breaking within capillaries. Carriers have symptoms only if they are deprived of oxygen (for example, while climbing a mountain) or while severely dehydrated. The sickle-cell disease occurs when the sixth amino acid, glutamic acid, is replaced by valine to change its structure and function; as

such, sickle cell anaemia is also known as E6V. Valine is hydrophobic, causing the haemoglobin to collapse in on itself occasionally. The structure is not changed otherwise. When enough haemoglobin collapses in on itself, the red blood cells become sickle-shaped. In sub-Saharan Africa where malaria is endemic, prevalence of the disease is relatively high than in the non-endemic areas. Figures 1 and 2 display the geographical distribution of the sickle cell trait and malaria in Africa respectively.





Fig. 1: Distribution of the sickle-cell trait shown in pink and purple



Fig. 2: Historical distribution of malaria shown in green.

The gene defect is a known mutation of a single nucleotide; single-nucleotide polymorphism - SNP) (A to T) of the β -globin gene, which results in glutamic acid being substituted by valine at position 6. Haemoglobin S with this mutation is referred to as HbS,

as opposed to the normal adult HbA. The genetic disorder is due to the mutation of a single nucleotide, from a CTC to CAC codon on the coding strand, which is transcribed from the template strand into a GUG codon. This is normally a benign mutation, causing *no* apparent effects on the secondary, tertiary, or quaternary structure of haemoglobin in conditions of normal oxygen concentration. What it does allow for, under conditions of low oxygen concentration, is the polymerization of the HbS itself. The deoxy form of haemoglobin exposes a hydrophobic patch on the protein between the E and F helices. The hydrophobic residues of the valine at position 6 of the beta chain in haemoglobin are able to associate with the hydrophobic patch, causing haemoglobin S molecules to aggregate and form fibrous precipitates.

The allele responsible for sickle-cell anaemia can be found on the short arm of chromosome 11. A person that receives the defective gene from both father and mother develops the disease; a person that receives one defective and one healthy allele remains healthy, but can pass on the disease and is known as a carrier. If two parents who are carriers have a child, there is a 1-in-4 chance of their child developing the disease and a 1-in-2 chance of their child being just a carrier. Heterozygotes are still able to contract malaria, but their symptoms are generally less severe (Allison, 2009).

Due to the adaptive advantage of the heterozygote, the disease is still prevalent, especially among people with recent ancestry in malaria-stricken areas, such as Africa, the Mediterranean, India and the Middle East (Kwiatkowski, 2005). Malaria was historically endemic to southern Europe, but it was declared eradicated in the mid-20th century, with the exception of rare sporadic cases (Poncon, Toty & L'Amber, 2007).

The malaria parasite has a complex life cycle and spends part of it in red blood cells. In a carrier, the presence of the malaria parasite causes the red blood cells with defective

haemoglobin to rupture prematurely, making the plasmodium unable to reproduce. Further, the polymerization of Hb affects the ability of the parasite to digest Hb in the first place. Therefore, in areas where malaria is a problem, people's chances of survival actually increase if they carry sickle-cell trait (selection for the heterozygote).

In the USA, where there is no endemic malaria, the prevalence of sickle-cell anaemia among blacks is lower (about 0.25%) than in West Africa (about 4.0%) and is falling. Without endemic malaria, the sickle cell mutation is purely disadvantageous and will tend to be selected out of the affected population via natural selection. However, the African American community of the USA is known to be the result of significant admixture between several African and non-African ethnic groups, and also represents the descendants of survivors of the slavery and the slave trade. Thus, a lower degree of endogamy and, particularly, abnormally high health-selective pressure through slavery may be the most plausible explanations for the lower prevalence of sickle-cell anaemia (and, possibly, other genetic diseases) among African-Americans compared to Sub-Saharan Africans. Another factor limiting the spread of sickle-cell genes in North America is the absence of cultural proclivities to polygamy, which allows affected males to continue to seek unaffected children with multiple partners (Lesi & Bassy, 1972).

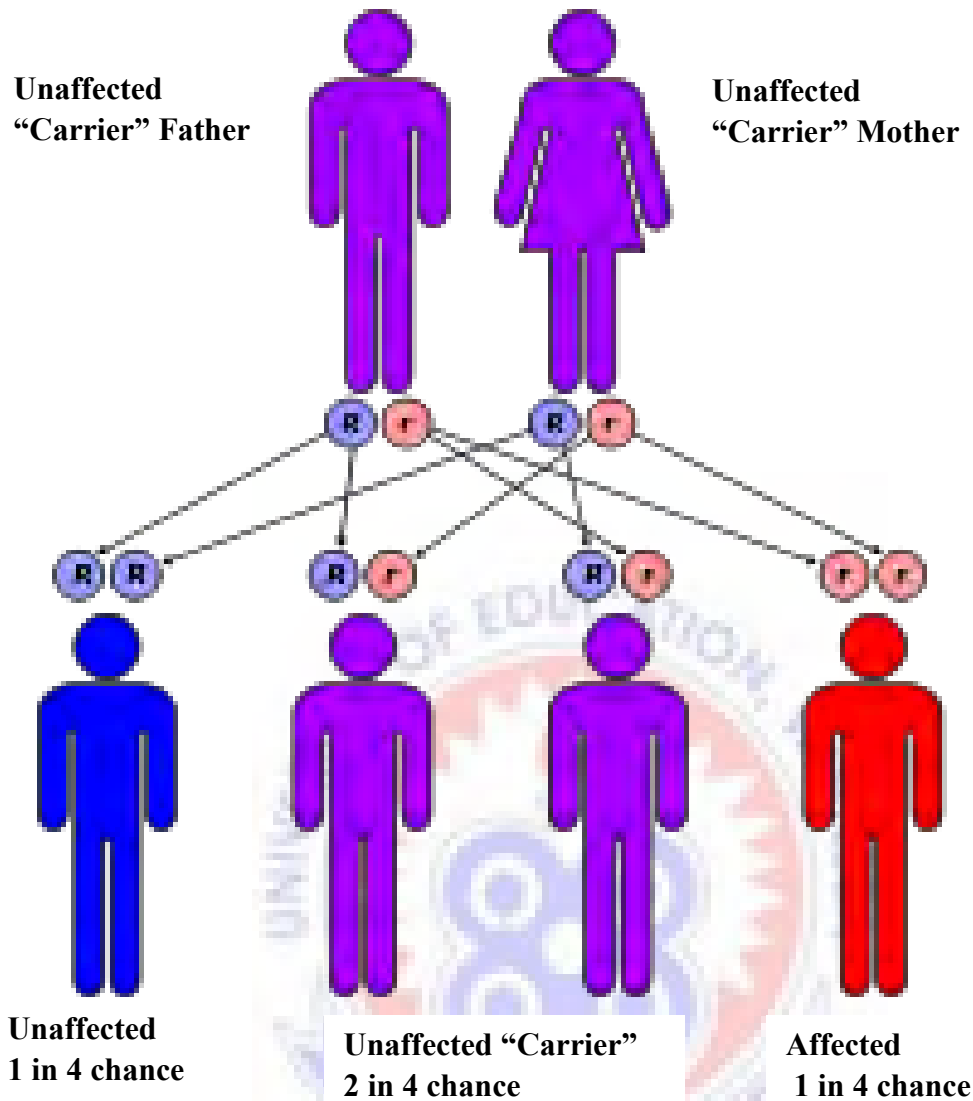


Fig. 3: Inheritance of Sickle cell disease in the autosomal recessive pattern.

Figure 3 depicts chances of inheritance of the first filial generation of offspring's from their carrier parents.

Sickle-cell conditions have an autosomal recessive pattern of inheritance from parents; this is similar to the mechanism in which blood type, hair colour and texture, eye colour, and other physical traits are inherited from biological parents. The types of haemoglobin a person makes in the red blood cells depend on what haemoglobin genes are inherited from his or her parents. If one parent has sickle-cell anaemia (SS) and the other has sickle-cell

trait then there is a 50% chance of a child's having sickle-cell disease and a 50% chance of a child's having sickle-cell trait. When both parents have sickle-cell trait a child has a 25% chance of sickle-cell disease, 25% will not carry any sickle cell alleles, and 50% will have the heterozygous condition, as shown in the diagram.

Symptoms of Sickle Cell Disease

The misshapen blood cells that are formed as a result of sickle cell disease can cause multiple problems and patients show many symptoms as a result. The majority of the symptoms are caused by the blockages that can form in the blood vessels of the patients.

Due to the irregular shape of the red blood cells, they cannot easily flow through the blood vessels in a linear formation like regular red blood cells, but instead they can clump together and form clots, constricting blood flow and oxygen supply. Symptoms of sickle cell disease include: irregular blood pressure, jaundice skin or eyes, pale skin, bone or joint pain, delayed growth, skin ulcers (common on the legs), anaemia, constant headaches, dizziness, fatigue, organ or tissue damage, pulmonary hypertension, shortness of breath, numbness in the extremities, and stroke. Sickle cell disease is known to be extremely painful in many instances due to the damage of the blood vessels.

History of prevalence of SCD in some countries

The highest frequency of sickle cell disease is found in tropical regions, particularly sub-Saharan Africa, India and the Middle-East (Weatherall, 2001). Migration of substantial populations from these high prevalence areas to low prevalence countries in Europe has dramatically increased in recent decades and in some European countries sickle cell disease has now overtaken more familiar genetic conditions such as haemophilia and cystic

fibrosis (Montalembert, 2007). In 2010, there were about 29,000 deaths attributed to sickle cell disease globally (Lozano, 2012).

Three quarters of sickle-cell cases occur in Africa. A recent WHO report estimated that around 2% of new-borns in Nigeria were affected by sickle cell anaemia, giving a total of 150,000 affected children born every year in Nigeria alone. The carrier frequency ranges between 10% and 40% across equatorial Africa, decreasing to 1–2% on the North African coast and <1% in South Africa (Anon, 2010).

The prevalence of the disease in the United States is approximately 1 in 5,000, mostly affecting Americans of Sub-Saharan African descent, according to the National Institutes of Health.

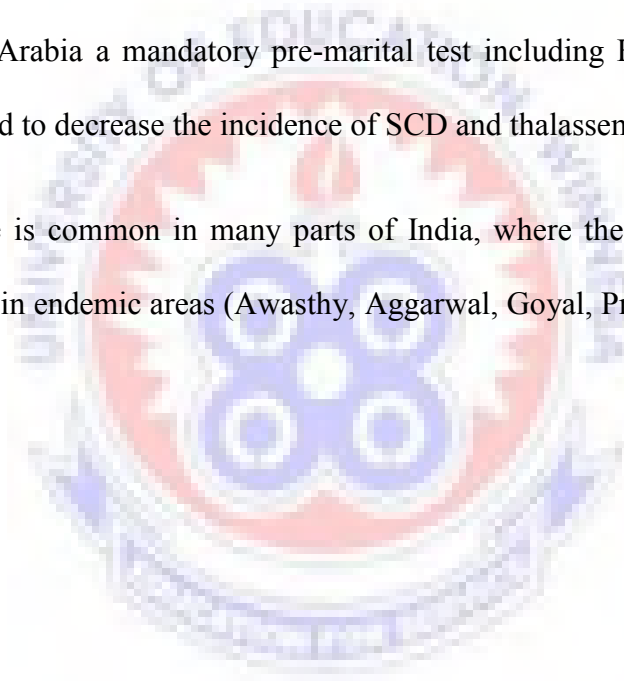
In the United States, about 1 out of 500 African-American children and 1 in every 36,000 Hispanic-American children born will have sickle-cell anaemia. It is estimated that Sickle Cell Disease (SCD) affects 90,000 Americans. Similarly, Sickle Cell trait occurs among about 1:12 African-Americans and 1:100 Hispanic-Americans (March of Dimes, 2008). It is also estimated that 2.5 million Americans are heterozygous carriers for the sickle cell trait. (Cinnchinsky, Mahoney & Landlow, 2011)

As a result of population growth in African-Caribbean regions of overseas France and immigration from North and sub-Saharan Africa to mainland France, sickle cell disease has become a major health problem in France (Bardakdjian, *et al.*, 2004). SCD has become the most common genetic disease in the country, with an overall birth prevalence of 1/2,415 in mainland France, ahead of phenylketonuria (1/10,862), congenital hypothyroidism (1/3,132), congenital adrenal hyperplasia (1/19,008) and cystic fibrosis (1/5,014) for the same reference period. In 2010, 31.5% of all newborns in mainland France (253,466 out of 805,958) were screened for SCD (this percentage was 19% in

2000). 341 newborns with SCD and 8,744 heterozygous carriers were found representing 1.1% of all newborns in mainland France. The Paris metropolitan district (Île-de-France) is the region that accounts for the largest number of newborns screened for SCD (60% in 2010). The second largest number of at-risk is in Provence-Alpes-Côte d'Azur at nearly 43.2% and the lowest number is in Brittany at 5.5 % (Bardakdjian-Michau, 2009).

In Saudi Arabia about 4.2% of the population carry the sickle-cell trait and 0.26% have sickle cell disease. The highest prevalence is in the Eastern province where approximately 17% of the population carry the gene and 1.2% have sickle cell disease (Jastaniah, 2011). In 2005 in Saudi Arabia a mandatory pre-marital test including HB electrophoresis was launched and aimed to decrease the incidence of SCD and thalassemia.

Sickle cell disease is common in many parts of India, where the prevalence has ranged from 9.4 to 22.2% in endemic areas (Awasthy, Aggarwal, Goyal, Prasad, Saluja & Sharma, 2008).



CHAPTER THREE

METHODOLOGY

Overview

The chapter describes the research design used for the study. It also describes the population, the sampling procedures, scoring instrument and its designs. The chapter ended with validation and reliability and the tools used to analyse the data.

Research Design

The research design that was used in the study was a descriptive sample survey. It determines Senior High School student's (SHS) conceptions of Sickle Cell Disease. Descriptive sample survey involved collecting data in order to test hypothesis or to answer research questions concerning the subject of study. The descriptive sample survey was also meant for the purpose of generalizing from a sample of a population so that references can be made about some characteristics, attributes or behaviour of the population. Since it was the purpose of the research to explore conceptions that S.H.S. students may had, the descriptive sample survey was considered the best.

Population

The target population consisted of all Senior High Schools in the Adentan Municipality, in the Greater Accra Region of Ghana. The accessible population, however, comprise two selected SHS's in the Adentan Municipality in the Greater Accra Region of Ghana.

Sample and Sampling Technique

A sample size of three hundred and thirty-one (331) students were obtained out of the total population of four hundred and fifty (450) forms one and two students, from the two (2) SHSs. Students were selected using simple random sampling (S.R.S); Ninety- six (96) and Two hundred and thirty-five (235) students from Delcam and West Africa SHS respectively.

Research Instrument

The main instrument used in the study to gather views and opinions was questionnaire. A questionnaire is normally used for the collection of data in educational research when information is to be obtained from a large number of subjects in diverse locations (Leedy, 1980). The questionnaire was supplemented with informal interviews.

Each questionnaire item was scored on a five-point Likert (Strongly agree 1, Agree 2, Disagree 3, Strongly disagree 4, No response 5). The first part of the questionnaire surveyed student's general conception of the disease (SCD) the second part measured scientifically proven concepts of SCD while the final part elicited students conceptions based on cultural / Religious, ethical and societal beliefs.

Validity of the Instrument

To ensure whether the questionnaire items measured what it was intended to measure, the questionnaire items were given to my supervisor and other lecturers in the Biology Education Department for thorough scrutiny to ensure that it measured the total content area of study. This was done to ensure face and content validity of the items.

Reliability of Instrument

A pre-test of the instrument was thereafter carried out on twenty (20) SHS 2 Biology students at Unity SHS in the Greater Accra Region of Ghana. This was done to exclude ambiguous questions and adjust challenging ones to suit the level of the target group of students. These students were used as a pilot test and did not form part of the sample for the study. Cronbach's alpha was determined on the data gathered using Statistical Package for Social Sciences (SPSS) software version (17). The output gave alpha coefficient of reliability of 0.991. According to George and Mallery (2003) a reliability coefficient value of 0.9 or more is rated excellent. This is an indication of a good internal consistency of a testing instrument.

Data Collection Procedure

The researcher personally administered the questionnaire. This enabled the researcher to ensure that the questionnaire items got to the respondents directly and helped in the establishment of a good rapport with the respondents. She also explains further any part of the questionnaires that pose a challenge to the respondents. Again, for respondents to be candid about their responses they were made aware of the fact that the questionnaire was for academic purposes only and information provided would be kept strictly confidential.

Data Analysis

Data obtained were analysed using tabulated frequency counts and percentages, bar charts and pie charts respectively. The first section of the questionnaire made up of six items was represented in tabular forms. These questionnaires focus on student's conception of the Disease as a concept. The second part emphasises on conceptions based on scientific proves and they were displayed in bar charts whiles the final part, which is based on

misconceptions motivated by Societal, Religious and Ethical beliefs consisting of six items, were presented in pie charts.



CHAPTER FOUR

RESULTS

Overview

This chapter presents the results obtained from the analysed data collected from the questionnaire. It is organised into three subsections. The first part presents the results of descriptive analysis on Student's conception about Sickle Cell Disease as a concept; the second part displays the results of the descriptive analysis on conceptions of the Sickle Disease based on scientific proves, and the third part also describes the results of the descriptive analysis on misconceptions motivated by Societal, Cultural and Ethical beliefs.

Analysis of Findings

Research Question 1:

What are Students' Conceptions about Sickle Cell Disease as a concept?

This subsection presents the results of analysis on the Conceptions students' have about Sickle Cell Disease as a concept. Tables 1-6 display the frequency and percentages of different items on the conceptions students' have about the disease.

Item 1

This item displays whether students understand the mode of infection of the disease as shown in the Table 1.

Table 1: Respondents' views on Diseases' Communicability.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	71	21.5
Agree	90	27.1
Strongly Disagree	88	26.6
Disagree	71	21.5
No Response	11	3.3
Total	331	100

As observed from Table 1, the percentage results of the respondents seems to be evenly distributed as 48.6% support the statement that sickle cell is communicable, but 48.1% were not in favour of the statement. However, 3.3% decided not to respond.

Item 2

Item 2 sought to test students' knowledge on the mode of transmission of Sickle Cell Disease and the response is displayed in Table 2.

Table 2: Mode of Transmission of Sickle Cell Disease.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	114	34.4
Agree	93	28.0
Strongly Disagree	60	18.1
Disagree	60	18.1
No Response	4	1.2
Total	331	100

In Table 2, majority (62.4%) of the respondents agree that the disease is transferred from one person to another through blood transfusion followed by 36.2% who disagreed, and 1.2% not responding.

Item. 3

This item assesses whether victims of the disease experiences anaemic conditions (Table 3).

Table 3: Effects of Sickle Cell Disease on patients' blood level.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	104	31.4
Agree	107	32.3
Strongly Disagree	55	16.6
Disagree	57	17.2
No Response	8	2.4
Total	331	100

Table 3 also depicts results having 63.7% of the respondents agreeing to the statement while 33.8% proved otherwise. However, 2.4% decided not to respond to the statement.

Item 4

Item 4 assesses whether parents with the sickle cell traits would produce children without the traits as displayed in Table 4.

Table 4: Possible outcome of offspring from Carrier Parents.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	80	24.1
Agree	88	26.5
Strongly Disagree	83	25.0
Disagree	73	22.0
No Response	7	2.1
Total	331	100

Table 4 describes results from item 4 with 50.6% agreeing to the fact that parents with sickle cell traits in their blood may bear children without sickle cell traits , 47% on the other hand disagreed while 2.2% did not respond.

Item 5

Item 5 determines whether carriers of the disease are resistant to malaria as depicted in Table 5.

Table 5: Phenotypic response of Carriers to the malaria parasites.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	57	17.2
Agree	70	21.1
Strongly Disagree	97	29.3
Disagree	86	26.0
No Response	21	6.3
Total	331	100

Table 5 displays results obtained from the item 5 as 38.3% of the respondents agreed to the statement, 55.3% contrarily disagreed, and 6.3% remained silent.

Item 6

Item 6 assesses whether the study of genetics is difficult to students or not.

Table 6: Students views on the comprehension of Genetic principles of SCD.

LEVEL OF AGREEMENT	FREQUENCY	PERCENTAGES (%)
Strongly Agree	76	23.0
Agree	86	26.0
Strongly Disagree	67	20.2
Disagree	79	24.0
No Response	23	6.9
Total	331	100

Table 6 demonstrates results of respondents numbering 49.0% who were in agreement to the fact that the study of genetics is difficult, while 44.2% were of the view that it is manageable. The remaining 6.9%, however did not comment on the statement as shown in Table 6.

Results obtained for research question two

Are these conceptions based on scientific proves?

This subsection describes the results of analysis that assesses whether conceptions formed by student's about the disease are based on scientific proves. Figures 1-9, displays the percentages of different items on the conceptions.

Item 7

In Figure 4, 50.2% of the respondents agreed that the shape of a normal red blood cell is controlled by allele H, while 37.6% disagreed with the statement. However, 12.3% did not comment on the statement.

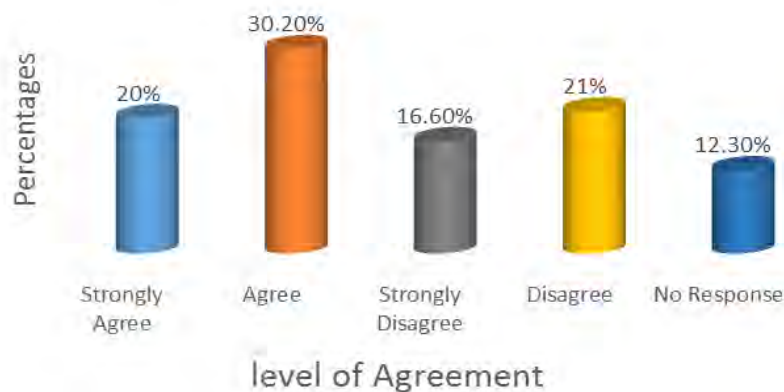


Fig. 4: Effects of Allele H on the shape of a normal red blood cell.

Item 8

As displayed in Figure 5, majority of the respondents were of the view that Allele S is responsible for the formation of abnormal haemoglobin while 36.2% of them proved false to the statement. On the other hand, 11.1% did not respond to the statement in the item 8.

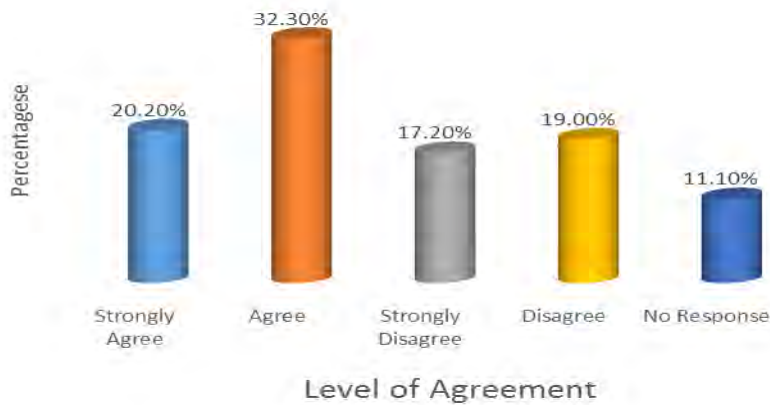


Fig. 5: Effects of Allele S on the formation of abnormal haemoglobin.

Item 9

Responses from the students indicating whether DNA or mutations cause new alleles to arise, results in the variation among organisms within a population are shown in Figure 6. Again, in that Figure it is clear that 49% of the respondents agreed to the statement in the item 9, while 36.8% conversely disagreed to the statement, and 14.2% gave no response.

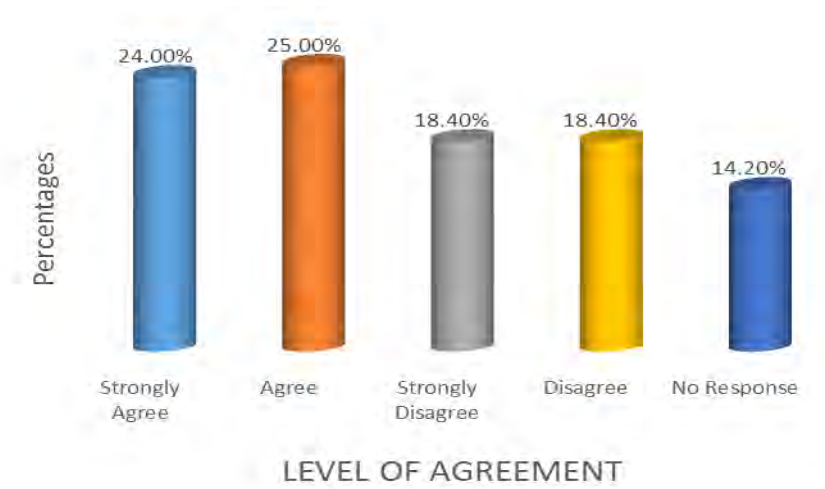


Fig. 6: Effects of DNA Mutations on allele formation

Item 10

Figure 7 depicts that majority (60.8%) of the respondents agreed to the statement in the item 10, which states that the possible genotypes for sickle cell disease are HH, HS, and SS whiles 32.9% proves otherwise, and 6.3% did not give any response.



Fig. 7: Possible genotypes for Sickle Cell Disease

Item 11

The above item was on the respondents' level of agreement on the possible probabilities that would be obtained from heterozygous sickled parents.

As shown in figure 8, a greater percentage of the respondents representing 55.3% agreed with the statement in item 11 as against 32.8% who disagreed, and 10.2% did not comment.

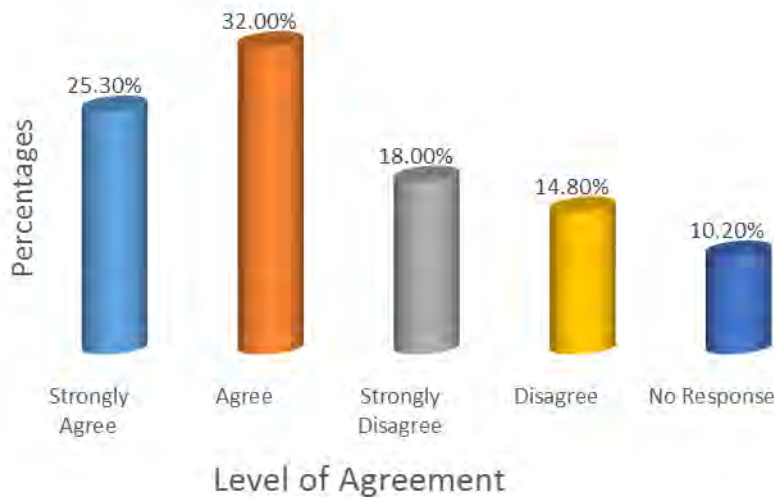


Fig. 8: Percentage probabilities of genotypes from heterozygous Sickled parent

Item 12

Item 12 sought to investigate students' response on the initial health status of babies infected with the disease.

Figure 9 presents results indicating 55.3% of the respondents who agrees that individuals with SCD are healthy at birth and become symptomatic later in infancy. On the contrary, 40.5% of the respondents' opposes the statement. Nevertheless, 4.2% of the respondents were silent on the statement.



Fig. 9: Health status of Individuals with Sickle Cell Disease at birth.

Item 13

Item 13 focuses on whether SCD can be cured or not.

Out of the sampled population, 40.5% of the respondents supported the statement that SCD can be cured through bone marrow transplant, while 48% disagreed with the statement. The rest of the population representing 12% remained silent on the statement in the item 13 as indicated in Figure 10.

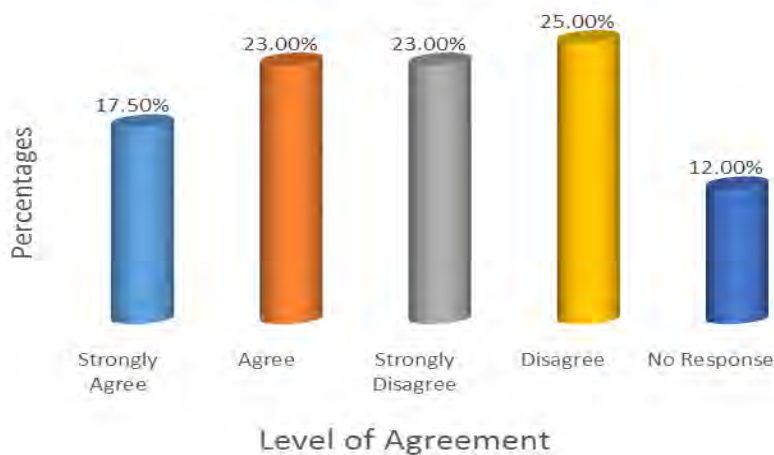


Fig. 10: Treatment of Sickle Cell Disease through bone marrow transplant

Item 14

As noted in Figure 11, 48.3% of the respondents agreed that sickle cell mutation is found on chromosome 11. But 33.2% of them refuted the fact that mutations of the disease are found on chromosome 11. However, 18.4% did not comment on the statement.

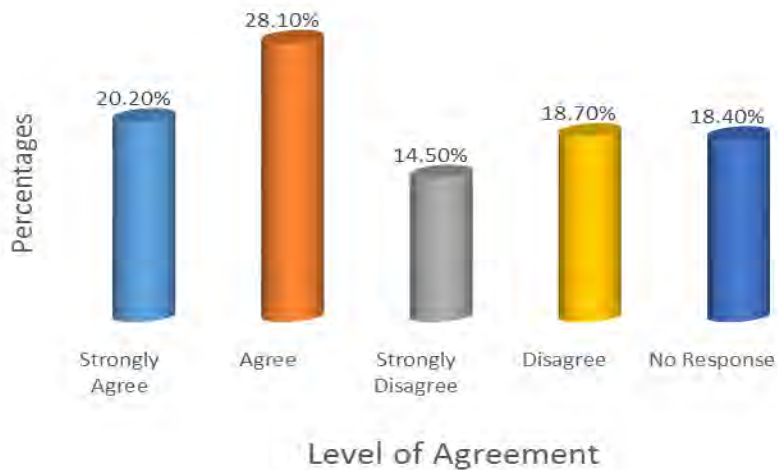


Fig. 11: Location of Sickle Cell mutation on chromosome 11

Item 15

Item 15 assesses whether environmental and genetic factors influence the severity of the disease.

Under this item, 57.1% of the respondents agreed that the severity of the disease is influence by both genetic and environmental factors, 34.5% disagreed whiles 8.4% gave no response.

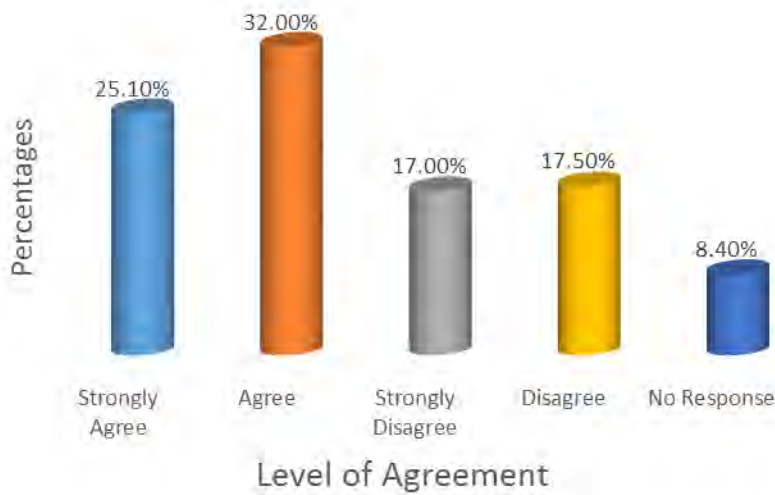


Fig. 12: Genetic and Environmental impact on the Disease

Research question 3

Are these misconceptions motivated by societal, cultural and Ethical beliefs?

This final subsection presents the results of analysis on the misconceptions motivated by societal, cultural and Ethical beliefs in pie charts. Figures 13-18 presents the percentages of different items on student's conception.

Item 16

The item 16 assesses student's conception on whether suitors must have a prior knowledge of their Sickle Cell status before marriage.

According to Figure 13, majority (73.4%) of the respondents agreed that suitors must know their sickle cell status prior to marriage, while 24.8% disagreed with the statement. However, 1.8% did not comment on the statement in Figure 13.

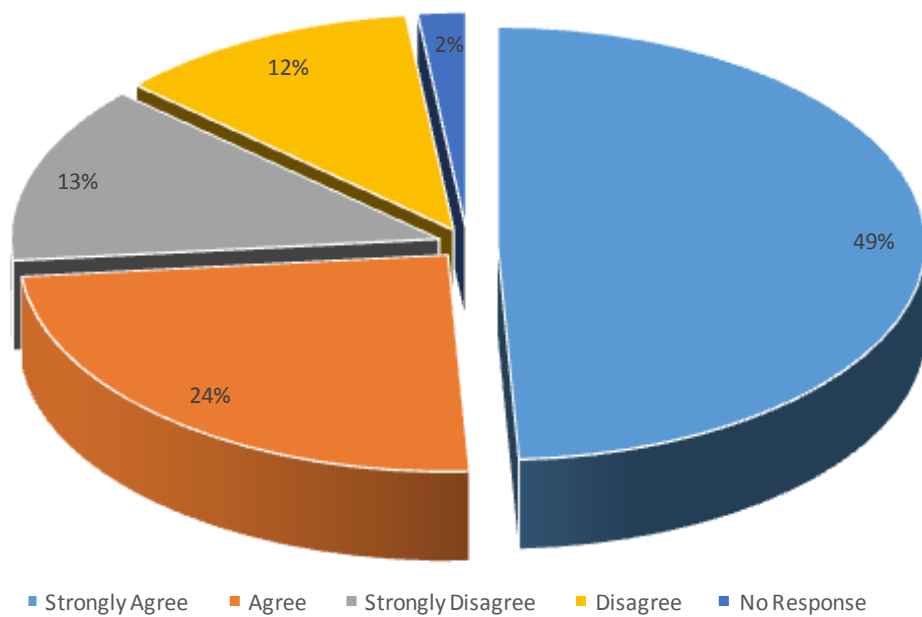


Fig. 13: Suitors knowledge of the Disease prior to marriage

Item 17

In this item, 55% of the respondents agreed that genetic test results of the sickle cell disease should be disclosed to affected peoples and their families. Conversely, 42.4% of the respondents disagreed with the statement while 3.0% of them did not respond to the statement in Figure 14.

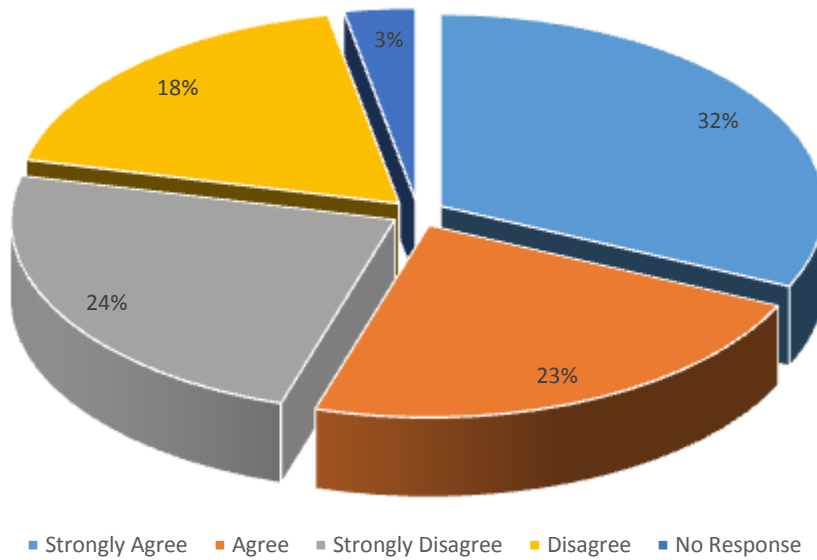


Fig. 14: Students' response to disclosure of test results to affected people

Item 18

As observed in Figure 15, 49% of the respondents were of the view that it is important to terminate a pregnancy affected by sickle cell disease. However, 46.5% of the respondents were not in favour of the statement, but for 5.0% of the respondents, they did not give any comment.

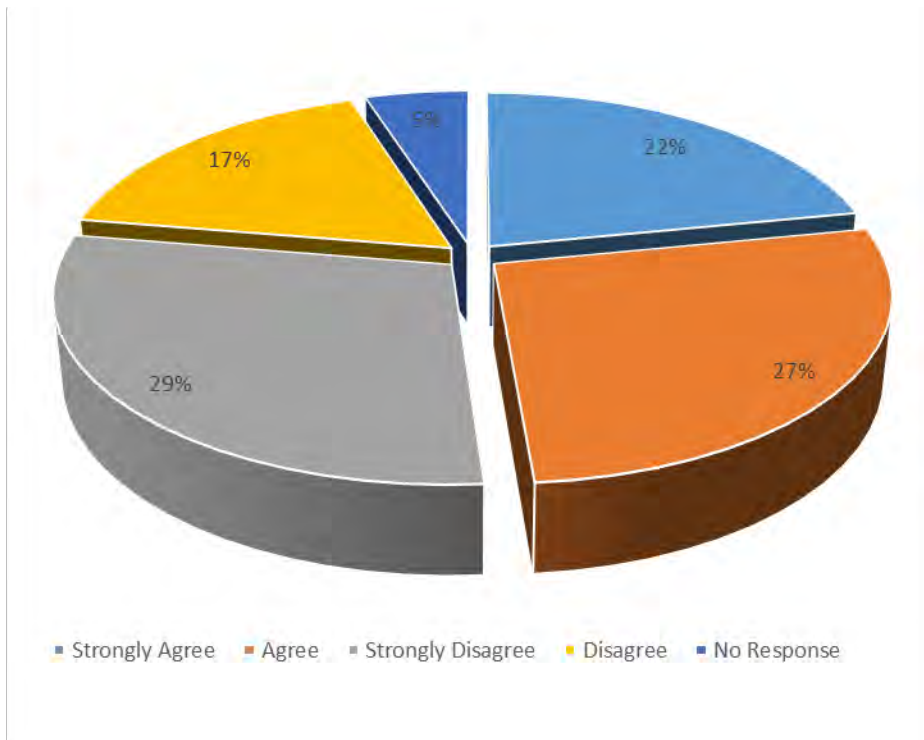


Fig. 15: Termination of pregnancy affected by Sickle Cell Disease.

Item 19

The statement in item 19 sought to determine student's conception on the race of people that are affected by the SCD.

Results obtained from the Figure 16 indicated that, 29.2% of the respondents agreed that SCD affect only people of the black race, majority of the respondents numbering 62.8% thought otherwise, the remaining 5.0% were silent on the issue raised.

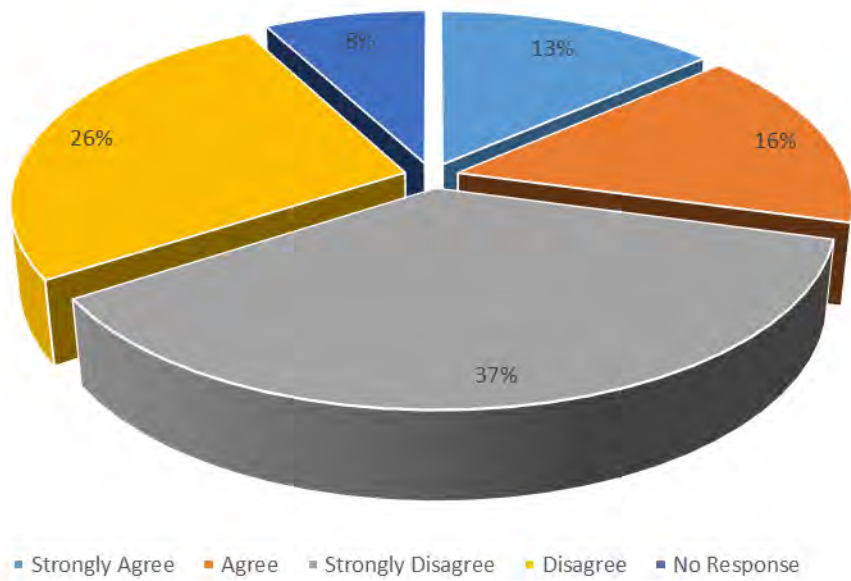


Fig. 16: Effects of Sickle Cell Disease on people of black origin.

Item 20

The statement in item 20 indicates that mutual love can lessen the burden of having children with SCD.

In Figure 17, 41.5% of the respondents agreed to the statement that mutual love can overcome the effects of bearing children, who have sickle cell disease, 49% proved false the statement. However, 10% remained silent.

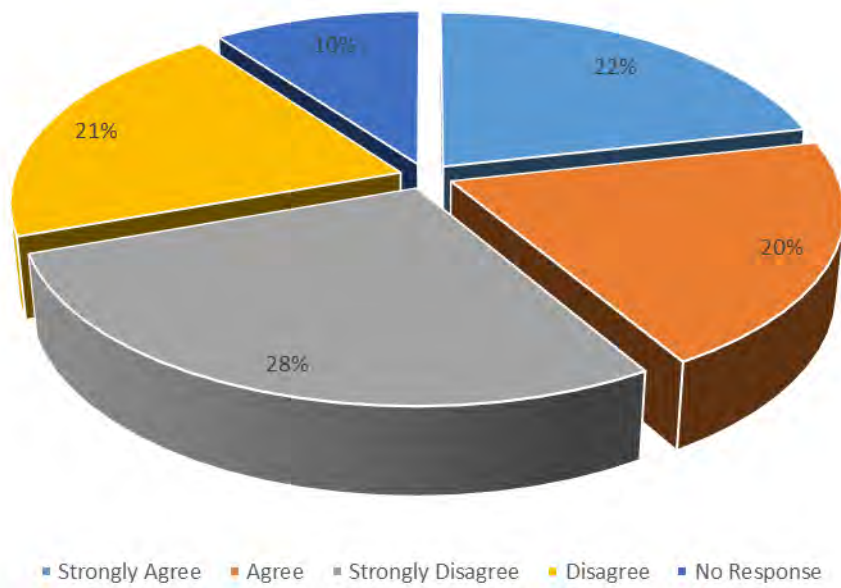


Fig. 17: Effects of Mutual love in managing disease' consequences.

Item 21

Item 21 presents a statement, which seeks to assess student's response on the role religion play on their conception of SCD.

Inferring from Figure 18, respondents numbering 54.0% agreed to the statement raised in the item 21, while 39.6% did not support the statement that divine intervention would safe parents from bearing children who are sicklers. The remaining 7% did not comment on the statement.

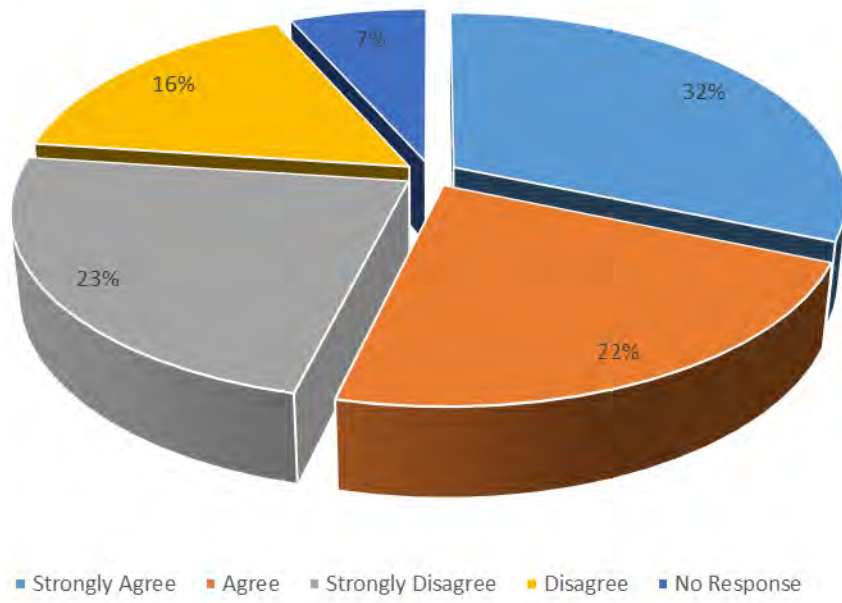


Fig. 18: Salvation from SCD through divine intervention.



CHAPTER FIVE

DISCUSSION, SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND AREAS FOR FURTHER STUDIES

Overview

This chapter presents discussions made on the results obtained from the analysed data collected from the questionnaire. It also includes summary of findings, conclusions, recommendations and areas for further studies.

Discussion

Research Question 1:

What are the student's conceptions about the sickle cell disease as a concept?

The analysis has brought to light series of misconceptions held by students with regard to research question posed. Inferring from the Item 1, 48.6% of the students agreed that sickle cell disease (SCD) is communicable whiles 48.1% disagreed. Indeed, this result clearly indicates a clear case of misconceptions about the mode of transmission of the sickle cell disease. Similarly, Item 2 presents results indicating majority (62.4%) of the students harbouring a misconception that the disease can be transferred from one person to another through blood transfusion. On the other hand, 36.2% of the students disagreed to the issue raised. According to Boujaoude (1992), students who frequently use rote learning tend to generate misconceptions concerning scientific concepts.

Again, the study found out that few students (33.8%) who responded to the item 3 did not know that people having the SCD suffer from anaemia. Even though the number of

students exhibiting ignorance to this statement is on the low side, it is still significant to cause for an alarm. The item 4 also presents students level of ignorance (50.6%) towards the statement that Parents with sickle cell traits in their blood may bear children without sickle cell traits. This case of misconception is quiet significant because according to Nyarvor, *et. al.*, (1991), when both parents have sickle cell trait, their offspring have a 25% chance of sickle-cell disease, 25% will not carry any sickle cell alleles and 50% will have heterozygous condition. This means ones chance of inheriting the sickle cell traits from such parents is high.

In addition, the study established again that several of the students (55.3%), who responded to the item 5 did not know that carriers of SCD are resistant to malaria. Likewise, some misconceptions again persisted among a number of the students; thus (49%) of students who answered the item 6 agreed that the study of genetics including the concept of sickle cell disease is difficult, whiles (44.2%) disagreed. Consequently, the results have been supported by Banet and Ayuso (2000) who argued that meaningful understanding of genetics is difficult and requires a certain level of abstract thought.

At the end of the study of the research question 1 the researcher discovered that 50% of the students who participated harboured levels of misconceptions of the SCD as a concept. However, 46.2% of the students had a sound knowledge of the concept whereas, 3.7% of the students gave no response. This revelations apparently confirms that most students had difficulties in comprehending the concept and as result have these alternative conceptions.

According to Fisher and Wandersee (2001), proliferation of research on student's conceptions has enhanced teachers understanding of preconception, misconceptions and alternative conceptions that students bring with them into the classroom. Currently, it is well accepted that alternative conceptions and misconceptions are common and these were

interfering with subsequent learning and are resistant to change. Results obtained has however, proved to be true. In related studies, researchers sought to highlight the factors that contribute to the difficulty and limited genetics education of health care. (Guttmacher, *et. al.*, 2007).

They therefore found out that several factors including, crowded curricula, lack of knowledgeable faculty; genetics content not well presented in a better way does not lead to long term knowledge retention, use of obsolete concepts or terms and flawed research were some of the causes of misconceptions (Hersey, 2004).

Research Question 2:

Are these conceptions based on scientific proves?

The study found out that, out of the total of 331 students who responded to the item 7, 50.2% of students did know that the shape of the normal red blood cell is controlled by an allele H, but for 37.6% of the students, they could not discern the scientific facts. This could emanate from the fact that some students did not have the ability to reason formally or in abstract terms. Most researchers have studied the reasoning ability of students and have consistently reported that the ability to reason formally is the strongest predictor of meaningful understanding of scientific concepts. Again, the study found out that majority (52.5%) of the students could discern that Allele S is responsible for the formation of abnormal haemoglobin whiles 36.2% disagreed. This results clearly demonstrated that a significant number of students still have some misconceptions or even alternative conceptions concerning the allele that is responsible for SCD.

Response from the Item 9 also revealed some level of misconceptions as 49% of the students agreed that changes in DNA cause new alleles to rise, leading to variations among organism, 36% could not comprehend the concept and therefore disagreed. Again, Cavallo

and Schafer (1994) defined learning orientation as the extent to which learners use meaningful or rote approaches to learning new information. Students with meaningful learning orientation try to make connections among concepts, whereas, students who do not possess a meaningful learning orientation concentrate on memorising ideas, concepts and facts. Perhaps students who could not give correct answers may have learnt the concept of genetics by rote and therefore could not make connections among the concept.

Results obtained from the item 10 indicated that, 60.8% of students had knowledge on the possible genotypes for sickle cell disease but 32.9% erroneously disagreed. In addition, the study also established that, when response were elicited from students on Item 11, 57.3% of the students knew the percentage distribution of normal red blood cells in a heterozygous person while 32.8% could not give a correct answer. These erroneous ideas could be due to the fact that students did not have any previous relevant knowledge on the concept, had their minds preoccupied with other things and also had low reasoning ability. Cavallo and Schafer (1994) found out that meaningful learning orientation and prior knowledge of meiosis were significant predictors of student's meaningful understanding of meiosis.

In another study, Cavallo (1996) explored the relation among students meaningful learning orientation, reasoning ability and acquisition of genetic topics. He concluded that students' use of meaningful learning was most important for understanding genetics concepts, whereas formal reasoning was most important for solving genetics problems. Item 12 produced results indicating 55.3% of students having knowledge on the health status of infants affected by SCD at birth while 40.5% of students did not have any clue to that effect. It is quite obvious that a sizable proportion of students have misconception persisting in their minds. Similarly, Item 13 also recorded some fair level of

misconceptions. It was discovered that 40.5% of students knew that SCD can be cured through bone marrow transplant but 48% of the respondents were not expose to that fact.

Inferring from the items 14 and 15, there have still been records of persistent display of misconceptions as 48.3% and 57.1% exhibited sound knowledge of the issues raised respectively, 33.2% and 34.5% also held firmly unto their alternative concepts that were not scientifically proven. Indeed, the results obtained were not surprising because Nigeria who has the highest population of sickle cell anaemia patients in the world, produced similar reports. Studies conducted by Adeola, *et. al.* (2012) among 403 health professionals, produced poor levels of awareness of the availability of prenatal screening services, 13.7% and 11.3% of health professionals were not aware or not sure that sickle cell anaemia can be prevented by prenatal screening.

Researchers have discovered that genetics remains conceptually and linguistically difficult to teach and learn (Tsui & Treagust, 2007). Prior research focusing on students understanding of core genetics concepts such as DNA, RNA and Chromosome suggest that the simultaneous exposure to objects and processes at the macro and molecular levels of organisation and the scarcity of direct concrete experiences with these ideas has made their learning difficult (Bahar *et. al.*, 1999).

Research Question 3:

Are these Conceptions motivated by Societal, Cultural and Ethical beliefs?

The analysis of the study has revealed that majority of the respondents population believed in having prior knowledge of their Sickle Cell status before marriage is vital. However, 24.8% of students thought otherwise. Again, there is still display of alternative conception.

In the item 17, 55% of the respondents believed that, test results of SCD should be disclosed to affected people and their families, on the contrary; 42% felt it should be kept away from them; obviously, these minority support the Ghanaian proverb which says “if you fidget with a corpse eye, you would see a ghost” so these group of subjects would prefer to remain in the dark than to be expose to the fact.

Several levels of beliefs were exhibited: as significant number of students confirmed that SCD does not affect only people of black origin, others also expressed conceptual difficulties in believing that divine intervention would save parents from bearing children who are sicklers.

In similar studies carried out by Brown (2011) in the United States, he has encountered many whose understanding of the disease is limited to the brief statement „It’s a black disease“. This statement is rather unfortunate but notwithstanding, the disease is said to be prevalent among people with recent ancestry in malaria stricken areas such as Africa, the Mediterranean, India and the middle East (Kwiatkowski, 2005). Likewise, in Nigeria researchers also discovered that religion is a major factor militating against acceptability of prenatal screening services of SCA.

Finally in Ghana, findings from a study conducted in the Northern part of the country by Boateng (2014) revealed that a section of the people believes that the disease is a curse from the gods. These have resulted in frequent stigmatization and discrimination meted

out to people with SCD and this has led to a further sense of isolation from family and society.

According to Brunner (1968), a child's cognitive development is dependent on the culture he/she is immersed in and also, different cultures provide different influences at different times in a child's life. It is therefore not surprising to have 41.0% of the respondents harbouring a wide range of conceptual difficulties that impede their comprehension of the concept of SCD but rather being influenced by Social, Cultural and Societal beliefs.

In these dispensations, where there is proliferation of religious activities, students' conceptual comprehension is being challenged and therefore requires extensive work from teachers to combat these obstacles.

Summary of Findings

The first phase of the questionnaire consisting of six items focused on answering research question one, which sought to find out the student's conception of the Sickle Cell Disease as a concept. The study revealed that 50% of the subjects have various levels of misconceptions of the SCD as a concept. Conversely, 46% had a sound knowledge of the concept while 3.7% of the subjects were undecided.

The second phase of the questionnaire consisting of nine items sought to address research question two which stated whether the assumed conceptions were based on scientific proves? Again, it was discovered that 36.9% of students exhibited misconceptions that were not scientifically proven.

In the third and final phase of the questionnaire, research question elicited response from subjects on conceptions that were culturally, ethically and societally motivated. Response collated indicated that, 41.0% of the respondents harboured a wide range of conceptual

difficulties and/or were influenced by factors that emanated from their ethical, social and cultural beliefs. On the contrary, 53.7% of the research subjects who responded to the question had insights that were at variance with their beliefs. However, 5.3% of the students remained neutral.

Conclusions

The results of the study showed that, some students of Delcam and West Africa Senior High Schools harboured some misconceptions that were motivated by the Society, Ethics and cultures that they were immersed in. These misconceptions contradicted genetic processes.

Based on these facts obtained, researcher therefore concludes that teachers must change the old traditional method of teaching to being facilitators, and guiding students to discard, modify, integrate and form concepts that are accurate and scientifically proven. Teachers should also endeavour to assess prior knowledge on concepts to be taught before instruction. Teacher's prime objectives must not be centered on student's ability to pass exams but to enhance content presentation that would ensure long-term knowledge retention that would guide students to make informed choices concerning their marriages and those of others in society and the country as a whole.

Finally, genetics is considered as one of the most important and difficult topics in science curriculum (Bahar, *et. al.*, 1999), and therefore, teachers have the herculean task of developing strategies to make the imaginary, theoretical and abstract topics in genetics to concrete, realistic ones for students to easily understand and appreciate.

Recommendations

The following recommendations have been made for consideration:

1. Biology Teachers in West Africa and Delcam Senior High Schools should endeavour to assess students' prior Knowledge on concepts to be taught before instruction.
2. Biology Teachers in West Africa and Delcam Senior High Schools must emphasise on content presentation that would ensure long- term knowledge retention.
3. Biology Teachers in West Africa and Delcam Senior High Schools should provide a learning environment that fosters scientific reasoning and encourages students to develop a meaningful learning approach.

Areas for Further Studies

In future research, proposal is made on the following topics:

1. Conception of Sickle Cell Disease amongst Biology teachers in Senior High School.
2. Prospective Biology teachers' attitude towards teaching genetics in Senior High Schools.
3. Conception of Sickle Cell Disease amongst SHS students in the central region.

REFERENCES

- Abraham, M. R., & Renner, J. W. (1986). The sequence of learning cycle activities in high school chemistry. *Journal of Research in Science Teaching*, 23, 121-143.
- Adeola A. B., Nwodo, V., & Njokanma, O. F. (2012). "Prenatal Screening for sickle cell Anemia": Awareness among Health professionals and medical students at the Lagos University Teaching Hospital and the concept of prevention by termination. *Journal of Pediatric hematology Oncology*, 34 (4), 252-256. From www.ncbi.nlm.nih.gov/pubmed?term=Adeola+Animasum+Barakat [au]
- Allison, A. C. (2009). Genetic control of resistance of human malaria. *Current Opinion in Immunology*, 21 (5), 499-505.
- Alparslan, C., Tekkaya, C., & Geban, O. (2003). Using the conceptual change instruction to improve learning. *Journal of Biological Education*, 37, 133-137.
- Anderman, E. M., & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching*, 31, 811-831.
- Ausubel, D. P. (1963). *The psychology of meaningful verbal learning*. New York: Grune & Stratton.
- Awasthy, N., Aggarwal, K. C., Goyal, P. C., Prasad, M. S., Saluja, S., & Sharma, M. (2008). Sickle cell disease: Experience of Tertiary Care Centre in a non-endemic area. *Annals of Tropical Medicine and Public Health*, 1 (1), 1-4.
- Bahar, M., Johnstone, A. H., & Sutchliffe, R. G. (1999). Investigation of students' cognitive structure in elementary genetics through association tests. *Journal of Biology Education*, 33(3), 134-142.
- Baker, W. P., & Lawson, A. E. (2001). Complex instructional analogies and theoretical concept acquisition in college genetics. *Science Education*, 85, 665-683.

- Balci, S., Cakiroglu, J., & Tekkaya, C. (2006). Engagement, exploration, explanation, extension, and evaluation (5E) learning cycle and conceptual change text as learning tools. *Biochemistry and Molecular Biology Education*, 34(3), 199-203.
- Banet, E., & Ayuso, E. (2000). Teaching genetics at secondary school: A strategy for teaching about the location of inheritance information. *Science Education*, 84, 313-351.
- Bardakdjian, J., & Wajeman, H. (2004). Epidemiology of sickle cell anaemia, *Rev Prat in French* 54(14), 1531-1533. Accessed from www.ncbi.nlm.nih.gov/pubmed/18582733.
- Bardakdjian-Michau, J., Bahuau M., & Hurtrel, D., Godart, C., Riou, J., Mathis, M., Goossens, M., Badens, C., Ducrocq, R., Elion, J., Perini, J. M. (2009). Neonatal screening for sickle cell disease. *Journal of Clinical Pathology*, 62(1), 31-33.
- Barker, V. (2004). Beyond Appearances: *Students misconceptions about basic chemical ideas: A report prepared for the Royal Society of chemistry*: Accessed from <http://www.chemsoc.org/pdf/LearnNet/rsc/miscon.pdf>.
- Barman, C. R., Barman, N. S., & Miller, J. A. (1996). Two teaching methods and students' understanding of sound. *School Science and Mathematics*, 96, 63-67.
- Boateng, S. K. (2014). Pain from a cursed Cell. In; *Radio (Joy FM) Documentary*: Accra, Ghana. (March 13, 2014)
- BouJaoude, S. B. (1992). The relationship between students' learning strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching*, 29, 687-699.
- BouJaoude, S. B., & Giuliano, F. J. (1994). Relationships between achievement and selective variables in a chemistry course for non-majors. *School Science and Mathematics*, 94, 296-302.
- Boulton-Lewis, G. M., Wilss, L., & Lewis, D. C. (2001). Changes in conceptions of learning for indigenous Australian university students. *British Journal of Educational Psychology*, 71, 327-341.

- Brown, S. - E. (2011), Cultural Models of Genetic Screening and Perceptions of Sickle Cell Disease in High-Risk Guadeloupean French Communities. Doctoral Dissertation, Guadeloupe, French West Indies. Retrieved January, 2011, from <http://digitalcommons.uconn.edu/dissertations/AA13464320>
- Bruner, J. S. (1968). *Processes of cognitive growth: infancy*. Worcester Mass Clark University press and Barea Publications.
- Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, 13, 325–351.
- Cavallo, A. M. L. (1996). Meaningful learning, reasoning ability, and students' understanding and problem solving of topics in genetics. *Journal of Research in Science Teaching*, 33, 625-656.
- Cavallo, A. M. L., & Schafer, L. E. (1994). Relationships between students' meaningful learning orientation and their understanding of genetics topics. *Journal of Research in Science Teaching*, 31, 393-418.
- Cavallo, A. M. L., Rozman, M., & Potter, W. H. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics*, 104, 288-300.
- Cavallo, A. M. L., Rozman, M., Blickenstaff, J., & Walker, N. (2003). Learning, reasoning, motivation and epistemological beliefs: Differing approaches in college science courses. *Journal of College Science Teaching*, 33, 18-23.
- Çayci, B., Demir, M. K., Başaran, M., & Demir, M. (2007). Concept Teaching via Cooperative Learning in Social Sciences Class. *Kastamonu Education Journal*, 15(2), 619–630.
- Cepni, S., Tas, E., & Kose, S. (2006). The effects of computer-assisted material on students' cognitive levels, misconceptions and attitudes towards science. *Computers and educations*, 46 (2), 192-205.
- Chin, C., & Brown, D. E. (2000). Learning in science: a comparison of deep and surface approaches. *Journal of Research in Science Teaching*, 37, 109–138.

- Cho, H. - H., Kahle, J. B., & Nordland, F. H. (1985) an investigation of High school biology textbooks as a source of misconception and difficulties in genetic and some suggestions for teaching genetic. *Science Education*, 69, 707-719.
- Chowing, J. T. (2000). Sickle Cell Anaemia. *Genetics Project and the genetics Education partnership*, from <http://genetics-education-partnership.mbt.washington.edu/Download/file.html>.
- Cinnchinsky, E. P., Mahoney, D. H., & Landlow, S. A. (2011). *Up to date: Sickle cell traits*: Retrieved 8 November, 2011. From <http://who.int/gb/ebwha/pdf.files/WHA59>.
- Colburn, A., & Clough, M. (1997). Implementing the learning cycle. *Science Teacher*, 64, 30-33.
- Dahlin, B., & Regmi, M. P. (1997). Conceptions of learning among Nepalese students. *Higher Education*, 33, 471-493.
- Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning. *Journal of Educational Research*, 93, 262-270.
- Dimitrov, D. M. (1999). Gender differences in science achievement: Differential effect of ability, response format, and strands of learning outcomes. *School Science and Mathematics*, 99, 445-450.
- Edwin, A. K. (2010). Frequent Stigmatization and Discrimination of people with SCD. Accessed on (March, 26, 2010), from www.ncbi.nlm.nih.gov/pmc/articles/PMC3282939.
- Eklund-Myrskog, G. (1997). The influence of the educational context on student nurses' conceptions of learning and approaches to learning. *British Journal of Educational Psychology*, 67, 371-381.
- Eklund-Myrskog, G. (1998). Students' conceptions of learning in different educational contexts. *Higher Education*, 35, 299-316.
- Finn, C. T. (2007). Increasing genetic education for psychiatric residents: *Harvard Review of Psychiatry*, 15(1), 30-33.

- Fisher, K. M., & Wandersee, J. H. (2001). *Mapping biology knowledge*. Dordrecht: Kluwer Academic Publishers.
- Gedik, E., Ertepinar, H., & Geban, O. (2002). *The effect of Demonstrative Experiment Based on Conceptual Change Approach on Overcoming Misconceptions in Electrochemistry Concept To the achievements of High School Students*. *National Science and Mathematics Education. METU: Ankara*, 162.
- George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference*. (4th ed.). Boston: Allyn & Bacon.
- Green, N. S., Fabry, M. E., Kapute-Noche, L., & Nagel, R. L. (1993). Senegal haplotype is associated with higher HbF than Benin and Cameroun haplotypes in African children with sickle cell anaemia. *American Journal of Hematology*, 44 (2), 145-146.
- Guttmacher, A. E., Porteous, M. E., & McNemey, J. D. (2007). Educating health professionals about genetics and genomics. *Nature Reviews*, 8, 151-157.
- Hackling, M. W., & Treagust, D. F. (1984). Research data necessary for meaningful review of grade ten high school genetics curricula. *Journal of Research in Science Teaching*, 21, 197–209.
- Haidar, H. A. (1988). *A comparison of applied and theoretical knowledge of concepts based on the particulate nature of matter*. Unpublished doctoral dissertation, University of Oklahoma, Norman.
- Hershey, D. R. (2004). *Avoid misconceptions when teaching about plants*. *American Institute' of Biological Sciences*. Retrieved October 13, 2011, from <http://www.actionbioscience.org/education/hershey.html>.
- Hoffman, K. J., Tambor, E. S., Chase, G. A., Faden, R. R. & Holtzman, N. A. (1993). Physicians Knowledge of genetics and genetic tests. *Academic Medicine*, 68 (18), 625-632.
- Jastinaniah, W. (2011). Epidemiology of sickle cell disease in Saudi Arabia: *Annals of Saudi Medicine*, 31(3), 289-93.

- Johnson, M. A., & Lawson, A. E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes? *Journal of Research in Science Teaching*, 35, 89-103.
- Karlsson, S. (2000). The first steps on the gene therapy pathway to anti-sickling Success. *Nature Medicine*, 6, 139-140.
- Karplus, R. (1977). Science teaching and development of reasoning. *Journal of Research in Science Teaching*, 14, 169-175.
- Knippels, M. C. P. J., Waarlo, A. S., & Boersma, K. T. (2005). Design criteria for learning and teaching genetics. *Journal of Biology Education*. 39, 108-112.
- Kose, S. (2008). Diagnosing student misconceptions: Using drawing as a research method. *World Applied journal*, 3(2), 283-293.
- Kwiatkowski, D. P. (2005). How malaria has affected the Human Genome and what Human Genetics can teach us about Malaria. *American Journal in Human Genetics* 77(2), 171-92.
- Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: a review of the research. *Journal of Research in Science Teaching*, 29(4), 331-359.
- Leedy, P. D. (1980). *Practical research planning and design*. New York: Macmillan Publishing Co. Inc.
- Lesi, F. E., & Bassy, E. E. (1972). Family study in sickle cell disease in Nigeria. *J. Biosoc Sci*, 4(3), 307-13.
- Lonka, K., Joram, E., & Bryson, M. (1996). Conceptions of learning and knowledge: does training make a difference? *Contemporary Educational Psychology*, 21, 240-260.
- Lozano, R., Naghavi, M., Foreman, K., *et al.*, (2012). Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for Burden of Disease study in 2010. *Lancet*. 380(9859): 2095-128.

- March of Dimes, (2008). *Achondroplasia*. Retrieved 5th December 2010, from <http://www.marchofdimes.com/baby/birthdefects/achondroplasia.html>.
- Marek, E. A., & Cavallo, A. M. L. (1997). *The learning cycle. Elements of school science and beyond*. Portsmouth, NH: Heinemann.
- Marek, E. A., Cowan, C. C., & Cavallo, A. M. L. (1994). Students' misconception about diffusion: How can they be eliminated? *American Biology Teacher*, 56, 74-78.
- Marshall, D., Summer, M., & Woolnough, B. (1999). Students' conceptions of learning in an engineering context. *Higher Education*, 38, 291-307.
- Marton, F., Watkins, D., & Tang, C. (1997). Discontinuities and continuities in the experience of learning: an interview study of high-school students in Hong Kong. *Learning and Instruction*: 7, 21-48.
- Montalembert, R. M. (2007). Sickle cell disease as a paradigm of immigration haematology: new challenges for haematologists in Europe, 865-71. Retrieved from <http://www.haematologica.org/cgi/content/full/92/7/865>.
- Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education*, 86, 548-571.
- Novak, J. D., & Godwin, D. B. (1984). *Learning how to learn*. Cambridge: Cambridge University Press.
- Nyavor, C. B., & Seddoh, S. (1991). *Biology for Senior Secondary School*. London: Macmillan Publishers Ltd.
- Ohene-Frimpong, K., Oduro, J., Tetteh, H., Nkrumah, F. (2008). Screening newborns for Sickle Cell Disease in Ghana. *Paediatrics*. (1219Suppl2): S120-S121. From www.ncbi.nlm.nih.gov/pmc/articles/PMC3282939/#CIT0002.

- Peebles, P., & Leonard, W. H. (1987). A hands-on approach to teaching about DNA structure and function. *The American Biology Teacher*, 49, 436–438.
- Piaget, J. (1950). *The psychology of intelligence*. New York: Harcourt Brace.
- Platt, O. S., Brambilla, D. J., & Rosse, W. F. (1994). Mortality in sickle cell. Life expectancy and risk factors for early death. *N. Eng. J Med*, 330 (23), 1639-1644.
- Poncon, N., Toty, C., & L'Ambert, G. (2007). Biology and dynamics of potential Malaria vectors in southern France. *Mala. J.* 6, 18.
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education*, 66, 211–277.
- Prosser, M., Walker, P., & Millar, R. (1996). Differences in students' perceptions of physics learning. *Physics Education*, 31, 43–48.
- Purdie, N., Hattie, J., & Douglas, G. (1996). Student conceptions of learning and their use of self-regulated learning strategies: a cross-cultural comparison. *Journal of Educational Psychology*, 88, 87–100.
- Purser, R. K., & Renner, J. W. (1983). Results of two tenth-grade biology teaching procedures. *Science Education*, 67, 85-98.
- Saunders, W., & Shepardson, D. (1987). A comparison of concrete and formal science instruction upon science achievement and reasoning ability of sixth grade students. *Journal of Research in Science Teaching*, 2, 39-51.
- Smith, M. U., & Sims, O. S. (1992). Cognitive development, genetics problem solving, and genetics instruction: A critical review. *Journal of Research in Science Teaching*, 29, 701-713.
- Soyibo, K. (1999). Gender differences in Caribbean students' performance on a test of errors in biological labelling. *Research in Science and Technological Education*, 17, 75-82.

- Stark, R., & Gray, D. (1999). Gender preferences in learning science. *International Journal of Science Education*, 21, 633-643.
- Stewart, J. H. (1982). Difficulties experienced by high school students when learning basic Mendelian genetics. *American Biology Teacher*, 44, 80-84.
- Sunal, D. W., & Sunal, C. S. (2003). *Science in the Elementary and Middle School*. In L. A. Montgomery (Ed.), the learning cycle. Upper Saddle River, NJ: Merrill-Prentice Hall, 34- 69
- Tekkaya, C., Capa, Y., & Yilmaz, O. (2000). Pre-service biology teachers' misconceptions about biology. *Journal of Hacettepe University Education Faculty*, 18, 140-147.
- Trigwell, K., & Prosser, M. (1991). Relating learning approaches, perceptions of context and learning outcomes. *Higher Education*, 22, 251–266.
- Tsai, C. - C. (1998). An analysis of Taiwanese eighth graders' science achievement, scientific epistemological beliefs and cognitive structure outcomes after learning basic atomic theory. *International Journal of Science Education*, 20, 413–425.
- Tsui, C. - Y., & Treagust, D. F. (2004). Conceptual change in learning genetics: An ontological perspective. *Research in Science and Technological Education*, 22, 185-202.
- Tsui, C. - Y., & Treagust, D. F. (2007). Understanding genetics: Analysis of secondary students' conceptual status. *Journal of Research in Science Teaching*, 44(2), 205–235.
- Turgut, M. F., Baker, D., Cunningham, R., & Piburn, M. (1997). *Science Education in Primary School*. Project of The Council of Higher Education of the Republic of Turkey/ The World Bank Developing National Education Pre-Service Teacher Education Publications, Ankara.
- Vygotsky, L. S. (1967). Play and its role in the mental development of children. *Soviet Psychology*: 5(3), 6–18.
- Weatherall, D. J., & Clegg, J. B. (2001). Inherited haemoglobin disorders an increasing global health problem. *Bull, World Health Organisation*, 79(8), 704-12.

Wellems, T. E., Hayton, K., & Fair, H. R. M. (2009). The impact of malaria

Parasitism: from corpuscles to communities. *J. clin. invest*, 119(9), 2496-505.

World Health Organization (WHO) (2010). Sickle Cell Anaemia. *Report by the*

Secretariat. Retrieved 27th November, 2010), from

(http://www.apps.who.int/gb/ebwha/pdf_files/WHA59/A59-9-en.pdf).



APPENDICES

SICKLE CELL ANAEMIA QUESTIONNAIRE

GENDER:

AGE:

RELIGION:

This questionnaire is designed to seek information for an essential project in academia. Please read carefully through each of the items and indicate the option that best expresses your views on the issues raised with a tick (✓). Every piece of information you give will be treated with the utmost confidentiality. Please be candid with the information you provide in order to make this survey correct and representative. Thank you.

STATEMENT	Strongly Agree	Agree	Strongly Disagree	Disagree	No response
1. Sickle Cell Disease is a communicable disease.					
2. The disease can be transferred from one person to another through blood transfusion.					
3. The shape of a normal red blood cell is controlled by an allele called H.					
4. Allele S is responsible for the formation of abnormal haemoglobin.					
5. People who have sickle-cells in their blood suffer from Anaemia.					
6. Parents with sickle cell traits in their blood may bear children without sickle cell traits.					
7. It is important for suitors to know their sickle cell status prior to marriage.					
8. Carriers of sickle cell disease are resistant to malaria.					
9. Changes in DNA, or mutations, cause new alleles to arise, leading to variation among organisms within a population.					

STATEMENT	Strongly Agree	Agree	Strongly Disagree	Disagree	No response
10. The possible genotype for the Sickle Cell Disease are HH, HS and SS.					
11. People who are heterozygous (HS) have about 60-70% of normal red blood cells and 30-40% of Sickle Cells in their body.					
12. Most individuals with Sickle Cell Disease are healthy at birth and become symptomatic later in infancy.					
13. Sickle Cell Disease can be cured through bone marrow transplant.					
14. Sickle Cell mutation can be found on chromosome II.					
15. Environmental and Genetic factors influence severity, of the disease.					
16. Genetic test results of sickle cell disease should be disclosed to affected pupils and their families.					
17. It is important to terminate a pregnancy affected by Sickle Cell Disease.					
18. Sickle Cell Disease affect only people of black origin or race					
19. The study of genetics which includes the concept of sickle cell disease is difficult.					
20. Mutual Love can enable couples to overcome the effects of bearing children who have the Sickle Cell Disease.					
21. Divine intervention would safe parents from bearing children who are Sicklers or Sickle Cell carriers.					



UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

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July 22, 2014

TO WHOM IT MAY CONCERN

INTRODUCTORY LETTER

The bearer of this letter, Ms. Esther Nuerterey is a Master of Education student in the Department of Science Education in the above University.

She is conducting a research in "SHS Students Conceptions of Sickle Cell Diseases in two Selected Schools in the Adentan Municipality".

Your school has been selected as part of her sampling area.

I hope you would assist her to do a good thesis write-up.

Thank you.

A handwritten signature in black ink, appearing to read "Dr. K. D. Taaie".

DR. K. D. TAAIE

Head of Department