UNIVERSITY OF EDUCATION, WINNEBA

BIOLOGY TOPICS PERCEIVED AS DIFFICULT TO LEARN BY SENIOR HIGH SCHOOL BIOLOGY STUDENTS IN THE MAMPONG AND EJURA-SEKYEDUMASE MUNICIPALITIES

GODFRED DANSO

2016

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8140130005

A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN SCIENCE EDUCATION

AUGUST, 2016

DECLARATION

Candidate's Declaration

I, **GODFRED DANSO**, hereby declare that apart from the references to other people's work which have been duly acknowledged, this work is the result of my own original investigation and that no part of it has been presented for another degree in this university or elsewhere.

Signature: …….

Date: …….

Supervisor's Declaration

I, hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines on supervision of this work laid down by the University of Education, Winneba.

Name of supervisor: Prof. K. D. Taale

Signature:……

Date:……

ACKNOWLEDGEMENTS

Firstly, I give glory to the Almighty God for granting me the strength and grace to go through this study. Indeed, if it is not the Lord, let people say. Father I thank you for how far you have brought me.

In my effort to complete this work, I was constantly guided by Prof. Kodjo Donkor Taale, a Professor in the Department of Science Education of the University of Education, Winneba. Sir, I am extremely grateful for your guidance, corrections and suggestions that have contributed immensely towards the success of this work. May the good Lord richly bless you.

My next appreciation goes to my family especially my wife who in diverse ways supported me in my study. Without her I could not have gone through this. Sweetheart, you are truly a good woman.

Finally, to all whose work were consulted to make this research a reality, I sincerely acknowledge my indebtedness.

DEDICATION

This piece of work is specially dedicated to my family and loved ones.

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ABSTRACT

The study was aimed at identifying topics perceived as difficult to learn in Senior High School biology, and how they can be solved in the Mampong and Ejura-Sekyedumase Municipal Assemblies of Ghana. Descriptive survey and purposive sampling technique were employed, and the data analysed using descriptive statistics. Twelve (12) biology teachers 50 out of 300 Senior High School students constituted the sample. The data was collected using questionnaire and interviews. All the biology teachers and students were interviewed. Results of the study show most difficult topics in descending order of difficulty as: classification, Mendalian genetics, protein synthesis, cell division (mitosis and meisosis), genes and chromosomes, skeletal system, cellular respiration, the Calvin cycle and evolution. Again, the following are reasons why students experience challenges when learning these difficult topics: the topics were characterized by complex terms and vocabulary, the abstract nature of the topics, the broad nature of the topics, teachers not conducting practical laboratory work but taught theoretically, lack of teaching and learning resources, and teachers' failure to cite practical examples students can relate with. The study also revealed that some teachers could not handle the difficult topics as evidenced by their poor explanation of concepts. The study established a variety of strategies that could help students learn the difficult topics effectively. These strategies included: strict lesson planning by teachers, the provision and effective use of teaching and learning resources, promoting active learner-centered teaching strategies, and employing effective communication skills characterized by clear explanations coupled with real-life practical examples. Based on the findings, appropriate recommendations were made.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter provides the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitations and delimitation of the study. The chapter ends with the organisation of the chapters.

1.1 Background to the Study

Science is a natural philosophy and largely responsible for the development of a nation's technological culture. It is the systematic and organized inquiry into the natural world and its phenomena. Science and technology is the bedrock of a nation's development, without which no nation can grow. When used effectively it is able to improve productivity and meet the needs of the society.

The classification of any nation into developed, developing and underdeveloped could be measured accurately by the number of chemists, physicists, engineers, pharmacists, doctors, agriculturalists and science educators the nation could produce. Ghana recognizes the immense contribution of science towards the growth of its economy, and it is in the light of this that Dr. Kwame Nkrumah placed much premium on science education. The University of Cape Coast (UCC) was established to train science teachers who will train science students to produce the required man-power. Also, the Akosombo Dam and the Ghana Atomic Energy were established to provide energy for the industries, and the setting up of the Centre for Scientific and Industrial Research (CSIR) was to provide ideas or

knowledge to enable the industries to function properly. The provision of special allowances to science teachers was to motivate them, and finally, the government scholarship scheme for science students. All these efforts were aimed at promoting science education in Ghana. Propelling the nation towards science and technology, as the engine of growth and inducing people with scientific minds (scientific literacy) to know and understand their environment better were the two main goals for science education in Ghana. Biology is one the most important science concepts that promote science and technology in a nation.

Various researchers have investigated difficulties students face in learning biology in other countries such as Scotland, Nigeria, Turkey and Israel (Johnstone & Mahmoud, 1980). Many concepts or topics in biology, including water transport in plants, protein synthesis, respiration and photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulation, oxygen transport, genetics, Mendelian genetics, genetic engineering, and the central nervous system have been perceived as difficult to learn by secondary school students (Çimer, 2012). Johnstone and Mahmoud (1980) reported that water transport in plants and genetics were among the most difficult biology topics to be leant by secondary school and university students. Tekkaya, Özkan and Sungur (2001) also found that hormones, genes and chromosomes, mitosis and meiosis, the nervous system, and Mendelian genetics were considered difficult concepts by secondary school students (Çimer, 2012). Finley, Stewart and Yarroch (1982) showed that cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis, were difficult and important topics for students to learn. Respiration and photosynthesis (Anderson, Sheldon & Dubay, 1990), gaseous exchange (Seymour &

Longdon, 1991), and concept of energy (Jennison & Reiss, 1991), were other topics which students find difficult to learn.

Bahar, Johnstone and HanselI (1999), found that monohybrid and dihybrid crosses and linkages, genetic engineering, meiosis, central nervous system, gametes, alleles and genes were perceived by Scottish first year university students as the topics of highest difficulty. Çimer (2012) also identified five topics that students had the most difficulties learning: matter, cycles, endocrine system and hormones, aerobic respiration, cell division, and genes and chromosomes.

Experiencing difficulties in so many topics in biology negatively affects students' motivation and academic achievement (Çimer, 2012; Özcan, 2003). There are many reasons why students have difficulties in learning biological concepts. The nature of science itself and its teaching methods are among the reasons for the difficulties in learning science. According to Lazarowitz and Penso (1992), the biological level of organization and the abstract level of the concepts make learning biology difficult. Overloaded biology curricula, the abstract and interdisciplinary nature of biological concepts, and difficulties in getting textbooks are the other factors preventing students from learning biology effectively (Chiapetta & Fillman, 1998; Tekkaya *et. al*., 2001). Chiepetta and Fillman (1998) stated that overloaded biology curricula may not contribute to students' achievement and lead them to learn the material through memorization, thus, preventing meaningful learning. Designing learning environments while ignoring students' interests and expectations cause several learning problems as well as decrease their interest in biology. Fraser (1998) and Çimer, (2004) indicate that there is a close relationship between students' perceptions of their classroom learning environment and their success. Osborne

and Collins (2001) also reported that students' diminishing interest in learning science was due to the curriculum content being overloaded, and also, not generally related to working life, the lack of discussion of topics of interest, the absence of creative expression opportunities, the alienation of science from society and the prevalence of isolated science subjects. Another reason reported by many researchers, specifically in Turkey, is that due to the nature of biological science, biology learning is generally based on memorization. Biological science includes many abstract concepts, events, topics and facts that students have to learn and this makes it hard for students to learn them. Teachers' styles of biology teaching and teaching methods and techniques may also be factors that affect students' learning in biology (Çimer, 2004). If students are not happy with the way that biology is taught, they may show disinterest in and negative attitudes towards biology and its teaching.

While adequate research has been conducted in other countries of the world as identified above in relation to biology topics perceived as difficult, very little research of this nature has been carried out in Ghana. Despite teachers' full knowledge of the difficulties that students face when learning some of these topics in biology, which actually lower their overall performance in biology examinations, teachers have taken no serious steps to address the situation. This is partly due to the teachers' lack of specific research-based information on how to teach such problem topics, and which could otherwise serve as a tool in alleviating the students' difficulties in learning the aforesaid topics.

1.2 Statement of the Problem

The difficulties most Ghanaian students have in some biological concepts have been reported in the Chief Examiner's Report for 2004 and 2011 WAEC biology paper, questions 4 in both years as:

Question 4 of 2004, Biology Paper:

(a) What is meant by each of the following terms:

(i) test-cross,

(ii) crossing over,

(iii) linkage?

(b) (i) What is variation?

(ii) What genetic factors bring about variation?

(iii) Explain how the consequences of variation are brought about.

The Chief Examiner Reports show that candidates performed poorly on this question and grossly displayed ignorance in genetics. He recommended that candidates should be encouraged to learn and understand genetic terms.

Question 4 of 2011 Biology Paper:

(a) Explain the following terms:

(i) diploid;

(ii) polygenic inheritance.

(b) (i) Explain the differences between sex linkage and autosomal linkage

(ii) Give two examples of a sex-linked characters.

(c) Mr. John who does not have the sickle-cell anaemia trait is married to Mary who is a sickler, yet he claims the sicker child born to them is not his child. Determine by aid of a genetic diagram whether his claim is true.

Again, he reports that this question was avoided by candidates. Candidates could not adequately explain the biological terminologies.

This study therefore is meant to establish the topics in biology which are perceived as difficult by Senior High School students and highlight some of the possible teaching strategies that biology teachers could employ to teach these difficult topics or concepts.

As noted above, most Senior High School students have exhibited unsatisfactory performance in some biology topics that are perceived as difficult to learn, and the reasons for their learning challenges are being researched on. While adequate research has been conducted in other countries of the world in relation to biology topics perceived as difficult, and students' learning challenges, very little research of this nature has been carried out in Ghana. The researcher, therefore, deems it necessary to identify the biological concepts or topics that are perceived to be difficult by senior high school students and to suggest teaching strategies that can be employed by biology tutors to teach such topics.

1.3 Purpose of the Study

The purpose of this study was to determine the topics in biology students perceive as difficult, and also to highlight some of the possible teaching strategies that biology tutors could use to teach such difficult topics.

1.4 Objectives of the Study

This study addressed the following objectives, that is to:

1. identify topics in biology that are perceived to be difficult by Senior High School students.
2. find out why the topics identified in (1) above are perceived to be difficult.
3. suggest possible practical teaching and learning strategies that would address students' learning difficulties in Senior High School biology and improve their performance of the difficult topics in the subject.

1.5 Research Questions

The study sought to find answers to the following questions:

1. What topics in biology are perceived to be difficult by Senior High School students?
2. What reasons do students attribute to these difficult topics?
3. What possible practical teaching and learning strategies would address students' learning difficulties to improve their performance of the topics perceived to be difficult in biology?

1.6 Significance of the Study

A lot of research have been done on students' difficulties in learning biology across the world. However, not much work, according to the literature, has been done on students' learning difficulties in biology in Ghana. The study is therefore important as it may provide useful data on students' learning difficulties in biology. It is hoped that data from this study may be useful to policy makers and curriculum designers in the Ministry of Education who

may prescribe some changes in teaching methods. The results of the study would equally be useful to educational institutions, school heads, biology tutors and other stakeholders who may wish to improve classroom teaching and learning. It is also hoped that this study will motivate other scholars to carry out similar research into pupils' learning difficulties in biology and other science subjects or scale up this work beyond the Mampong and Ejura-Sekyedumase Municipal assemblies.

1.7 Delimitation (Scope of the Study)

The study is delimited to the Mampong and Ejura-Sekyedumase Municipal Assemblies in the Ashanti Region of Ghana due to the familiarity that the researcher has concerning the area.

1.8 Limitation of the Study

This study, like any other research, has its limitations. Certain limiting factors that affected the validity and reliability of the results of the study were:

- Teachers' possibility of not being transparent in assessing themselves because of fear that they could be considered as not competent at teaching.
- Again, the possibility of not obtaining a hundred percent answers to questionnaires.
- Financial constraints.

1.9 Organization of Chapters

The study was arranged into five related chapters to ensure an orderly and systematic presentation of materials or information. Chapter one covers the introduction to the study, and it includes the background of the study, statement of the problem, purposes of the study, research questions, and significance of the study, delimitations, limitations, and

organization of chapters. Chapter two reviewed related literature. The chapter three described the methodology used for the study and included the population, sample and sampling procedure and methods used in the data collection. The chapter four provided the analysis and discussions of the findings of the study. Finally, the fifth chapter dealt with the summary, conclusions, recommendations and suggestions for further studies.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter reviews related literature on topics perceived as difficult and students' learning difficulties in biology, especially, the literature that has particular significance to this study. The review also attempted to relate similar studies to this study as a way of justifying the present research.

2.1 Perceived difficult biological concepts

Various researchers have investigated difficulties students face in learning biology in other countries such as Scotland, Nigeria, Turkey and Israel (Johnstone & Mahmoud, 1980). Many concepts or topics in biology, including water transport in plants, protein synthesis, respiration and photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulation, oxygen transport, Mendelian genetics, genetic engineering, and the central nervous system can be perceived as difficult to learn by secondary school students (Çimer, 2012). Johnstone and Mahmoud (1980) reported that water transport in plants and genetics were among the most difficult biology topics to be leant by secondary school and university students. Tekkaya, Özkan and Sungur (2001) also found that hormones, genes and chromosomes, mitosis and meiosis, the nervous system, and Mendelian genetics were considered as difficult concepts by secondary school students (Çimer, 2012). Finley, Stewart and Yarroch (1982) showed that cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis, were difficult and important topics for students to learn. Respiration and

photosynthesis (Anderson, Sheldon & Dubay, 1990), gaseous exchange (Seymour & Longdon, 1991), and concept of energy (Jennison & Reiss, 1991), were other topics which students find difficult to learn. Bahar, Johnstone and Hansell (1999) found that monohybrid and dihybrid crosses and linkages, genetic engineering, meiosis, central nervous system, gametes, alleles and genes were perceived by Scottish first year university students as the topics of highest difficulty. Çimer (2012) also identified five topics that students had the most difficulties learning: matter, cycles, endocrine system and hormones, aerobic respiration, cell division. In their work, Lazarowitz and Penso (1992) identified the Israeli high school students' learning difficulties in biology concepts such as cells, organelles, organs, and physiological processes, hormonal regulation, oxygen transport, controlled experiments and the principle of structure and function. In the light of the above, it is clear that some topics in biology are considered difficult to learn by students in the senior high schools.

2.2 Reasons for students' perceived difficulty in Biology concepts

Experiencing difficulties in so many topics in biology negatively affects students' motivation and academic achievement (Çimer, 2012; Özcan, 2003). There are many reasons why students have difficulties in learning biological concepts. The nature of science itself, language and specialist vocabulary of biology, students' attitude, students' mathematical background, teachers' academic and professional qualification and methods employed in the teaching of biology are among the reasons for the learning difficulties.

2.2.1 Language and Specialist vocabulary of Biology

Language plays a very important role in determining the degree of understanding of biological concepts (Bennett, 2003). Language is what communicates the ideas to the pupils, and that if the language is not learner friendly; pupils will inevitably experience learning difficulties in biology. This means, as Bennett (2003) observes, that understanding science is more than just knowing the meaning of particular words and terms but making meaning through exploring relationships among the words used. It is therefore a fact that as long as students fail to grasp the relationships among key biological terms under discussion, they will always have problems in conceptualizing what is being taught. As Young (1999) puts it, failure to understand the language associated with the biological terms gives rise to failure to grasp the biological concepts.

Bennett (2003) highlights the failure on the part of teachers to explain to the students what he refers to as 'specialist vocabulary' prior to actual learning. According to him, technical vocabulary associated with biological concepts has proved to be responsible for reducing the readability and understandability of the biological text which very often results in poor conceptualization. This implies that the inability of the teachers to explain 'specialist vocabulary' surrounding biological concepts is a clear manifestation of their inadequate understanding of the difficult topics such as genetics and DNA synthesis. Therefore, if teachers have a vague idea of what they want to teach, students will find it difficult to understand the concept. Ogunkola and Samuel (2011) point out that the many difficult terms and symbols used in the teaching of sciences are so new that they cannot be linked to the students' cognitive structures. The authors seem to emphasize the point that students' ability to comprehend some biology concepts is virtually blocked by the fact that they have

had no experience with the new terms. Tekkaya *et al.* (2001) in their work identified that, most of the students had difficulty in learning mitosis and meiosis concepts. These difficulties were attributed mainly to terminology and abstract level of the concept. Terminology, according to them is very complicated and includes many terms foreign in origin such as chromosome, gene, allele, chromatid, and DNA. Students always mixed these terms to each other, especially gene and allele. They generally memorized these concepts and forgot them after some time. Çimer (2012) also supports this reason for students' difficulty in some of the biological concepts and reveals that, "the main reason for this was that biology has a lot of concepts, various biological events that cannot be seen by the naked eye, some concepts are too abstract, and that there are a lot of foreign/Latin words". This is also well explained by the theoretical framework used in this study, that the construction of ideas and meaning of what students learn largely depends upon their prior knowledge and environment they are operating in. Looking at this, one might then ask, how the students would comprehend the concepts in biology if the vocabulary used is not understood. This is one factor which results in poor students' performance in biology (Bennett, 2003).

2.2.2 Nature of biological concepts

Some biological concepts are abstract in nature and students find it difficult to understand them. In a work by Çimer (2012) to identify what makes biology learning difficult in Turkey, the nature of the topics was identified as the main reason for their difficulty in learning. The main reasons for this were that biology includes a lot of concepts, various biological events that cannot be seen by the unaided eye, some concepts are too abstract,

and that there are a lot of foreign/Latin words. Similar findings were made by Tekkaya *et al.* (2001) in their work and concluded that most students had difficulty in learning mitosis and meiosis concepts because of their abstract level. Again, respiration and photosynthesis were perceived by students as difficult to learn because of the interdisciplinary nature of the concepts. Students should have mastered the concepts like chemical reactions, organic and inorganic molecules in their chemistry courses in order to understand the chemical nature of respiration and photosynthesis. Both studies also reported that the biology curriculum and biology textbooks in Turkish secondary schools included very detailed knowledge and covered topics or concepts that were difficult to learn and use in their daily lives. Students generally learn ecology easi1y because they transfer concepts of ecology to many contexts of everyday life. Cell and organelles are the other topics which were easily learnt by students (Tekkaya *et al*. 2001). According to Çimer (2012), many students revealed that the nature of biology forces them to memorize biological facts in order to learn them. Thus, memorization is common among Turkish secondary students as a biology-learning strategy. Therefore, the nature of biological concepts can be a hindrance to students' understanding of them.

2.2.3 Instructional materials/Resources

Instructional materials refer to any material that can be used for the purpose of demonstration during any lesson delivery. They are often they are referred to as teaching aids. A wide range of materials can be used for effective delivery of Biology lessons. Instructional materials such as models may illustrate in detail the points being made by the teacher and expand some of the presented details into broad general principles for better understanding (Adrine, 2005). They can arouse interest, stimulate discussion, and raise

questions and simplify information and ideas among learners. The use of instructional materials increases the quality of learning. They also increase the efficiency of teachers in terms of numbers of learners taught without reducing the quality of learning (Adrine, 2005). Thus, the presence of instructional materials or teaching and learning materials enhance students' understanding of biological concepts that are abstract in nature.

2.2.4 Teachers' teaching style

Quality education depends on effective instruction (Adrine, 2005). Thus, the choice of an appropriate instructional method is essential in promoting effective learning. Wood, Cobb and Yackel (1995) classified the teaching styles into three general categories: discipline-centered, instructor-centered, and student-centered.

In *discipline- centered* teaching, the needs, concerns and requirements of the teacher and student are not considered because the course depends on the content prepared. The teacher transmits information, but the content is dictated by some separate authority such as a department syllabus, committee or textbook author.

In *instructor-centered* teaching, the teacher acts as a model, is regarded as the authoritative expert, the main source of knowledge and the focal point of all activity. The student is the passive recipient of the information already acquired by the teacher.

Student-centered teaching focuses on the student and in particular on the cognitive development of the student. The teacher's goal is to help students grasp the development of knowledge as a process rather than a product. It leads to better retention and better transfer of knowledge to other situations, better motivation for further learning and better problem-solving ability (Brown, 1994).

Effective teaching of Biology can be achieved through practical involvement of students in learning activities, whereby the teacher only plays the role of a facilitator in the learning process. Often teachers find it difficult to select an instructional method that best suits a particular lesson situation. However, a particular teaching method will naturally flow into another, all within the same lesson and excellent teachers have developed skills to make the process seem less difficult to the students.

The work of Çimer (2012) revealed that biology lessons were generally carried out through teachers' lectures and could be identified as teacher-centered lessons. Practical work and student-centered activities in biology classes were merely used. This negatively affected students' learning of biology. Another factor related to the way biology is taught was the lack of a relationship between what was taught in the biology class and the participants' daily lives. Students stated that the biology lessons or teachers could not help them to connect what they had learned in the class and with their daily lives. This indicates that in biology lessons, teachers just talk and transfer theoretical or abstract knowledge and do not provide examples from daily life which they could relate to easily. As a result, students find it difficult comprehending the concepts and thus leading to learning difficulties.

2.2.5 Mathematical background

The topics such as genetics that students find difficult to learn have mathematical aspects. Students are required to calculate probability questions in genetics so much that if they have weak mathematical background they will find genetics a hard concept. Mullich (2009) identified that fluency in mathematics is needed to understand science, and lays emphasis on the fact that learning mathematics effectively before a student learns the topics in

biology which are mathematical in nature would be a helpful step, and would help students understand the biological concepts with much ease. This statement gives a clear impression that if students are not well equipped with enough mathematics, they may face challenges when it comes to learning biological topics that are mathematical in nature.

2.2.6 Students' attitude

Students may develop some attitudes towards the learning of biology when they experience difficulty in the subject. As Çimer (2012) puts it, "experiencing difficulties in so many topics in biology negatively affects students' motivation and achievement". Chiepetta and Fillman (1998) state that overloaded biology curricula may not contribute to students' achievement and lead them to learn the material through memorization, thus, preventing meaningful learning.

2.2.7 Students' learning styles

Learning style is the way in which human beings begin to concentrate on, absorb, process and retain new and difficult information (Dunn, 1999). The way in which an individual processes information eventually develops into the manner in which the individual delivers the information. To learn, we depend on our senses to process the information around us. Most people tend to use one of their senses more than the others whiles people switch learning styles depending on what they are studying. If a student possesses a particular learning style but is taught in a style that opposes the way he/she learns, the student will appear bored and disinterested. It does not necessarily mean no learning will take place. There will be some or little acquisition of knowledge. The process of attaining this

knowledge will take longer and it will be a difficult process for the student. Thus, if the teaching style matches the learning style of the student, the learning process becomes more efficient and more effective. A work conducted by Çimer (2012) indicated that student's learning and studying habits contributed to the difficulties they faced in learning biology. Therefore, the teaching style must match with students' learning styles if students are to easily understand what is being taught.

2.3 Teaching methods/strategies

Teaching strategy is the deliberate planning and organization of teaching and learning experiences and situations. In Ghana, the most commonly practiced arrangement used for teaching is the class teaching. A class is supposed to have similarities and this acts as the basis for choosing the content and method to use in teaching. Instruction is given to the class as a whole at a single time, so that what is being taught becomes easy to the high achieving students but may be too difficult for the low achieving ones.

A method is a procedure by which a goal is reached, purpose accomplished or a result achieved. Method of teaching can be described as a procedure or technique a teacher employs to help learners achieve the instructional objectives. Key factors in facilitating an effective learning environment in the science class are the teaching strategies used by teachers. As early as 1910, John Dewey criticized science teaching of the day as giving too much emphasis to the accumulation of information rather than to an effective method of inquiry (Ogunkola & Samuel, 2011). The type of teaching method a teacher adopts must be guided such factors as age, attainment levels of students, time frame, availability of resources and materials, subject matter, among others. The approaches for teaching can be broadly classified into teacher centered and student centered. In teacher-centered approach

to learning, teachers are the main authority figure in this model. Students are viewed as "empty vessels" whose primary role is to passively receive information (by lectures and direct instruction) with an end goal of testing and assessment. It is the primary role of teachers to pass knowledge and information onto their students. In this model, teaching and assessment are viewed as two separate entities. Student learning is measured through objectively scored tests and assessments. In student-centered approach to learning, while teachers are an authority figure in this model, teachers and students play an equally active role in the learning process. The teacher's primary role is to coach and facilitate student learning and overall comprehension of material. Student learning is measured through both formal and informal forms of assessment, including group projects, student portfolios, and class participation.

Teachers' styles of biology teaching and teaching methods and techniques affect students' learning in biology (Çimer, 2004). If students are not happy with the way that biology is taught, they may show disinterest in and negative attitudes towards biology and its teaching. The notion that learning is influenced by prior experiences and must be constructed by the learner has led to the development of what has become the dominant view of learning in science education today (Ajaja, 2013). The impact and influence of this view of learning has given rise to the development of new strategies of teaching science such as concept mapping, cooperative learning and learning cycle where the emphasis is on the active participation of learners in the learning process. All three instructional strategies share complimentary objectives of engaging students in the learning process and promoting higher thought processes and more authentic behaviours required for scientific and technological development. In the classroom where elements of constructivism are

incorporated in teaching and learning, students get opportunities to physically interact with instructional materials and engage in varied kinds of activities. This position suggests that for effective learning to take place, students must be actively involved in the learning process (Ajaja, 2013). These instructional strategies are described below:

2.3.1 Concept mapping

A concept map is a two-dimensional representation of the relationship between key ideas. When based on educational psychology theories of how we organize information, concept maps are hierarchical, with broader, more general items at the top and more specific topics arranged in a cascade below them. A standard concept map construction methods include the following series of steps (Ajaja 2013):

i. define the topic,
ii. list the most important concepts,
iii. arrange concepts hierarchically;
iv. add links to form a preliminary concept map;
v. add linking phrases
vi. add cross links, and
vii. review map

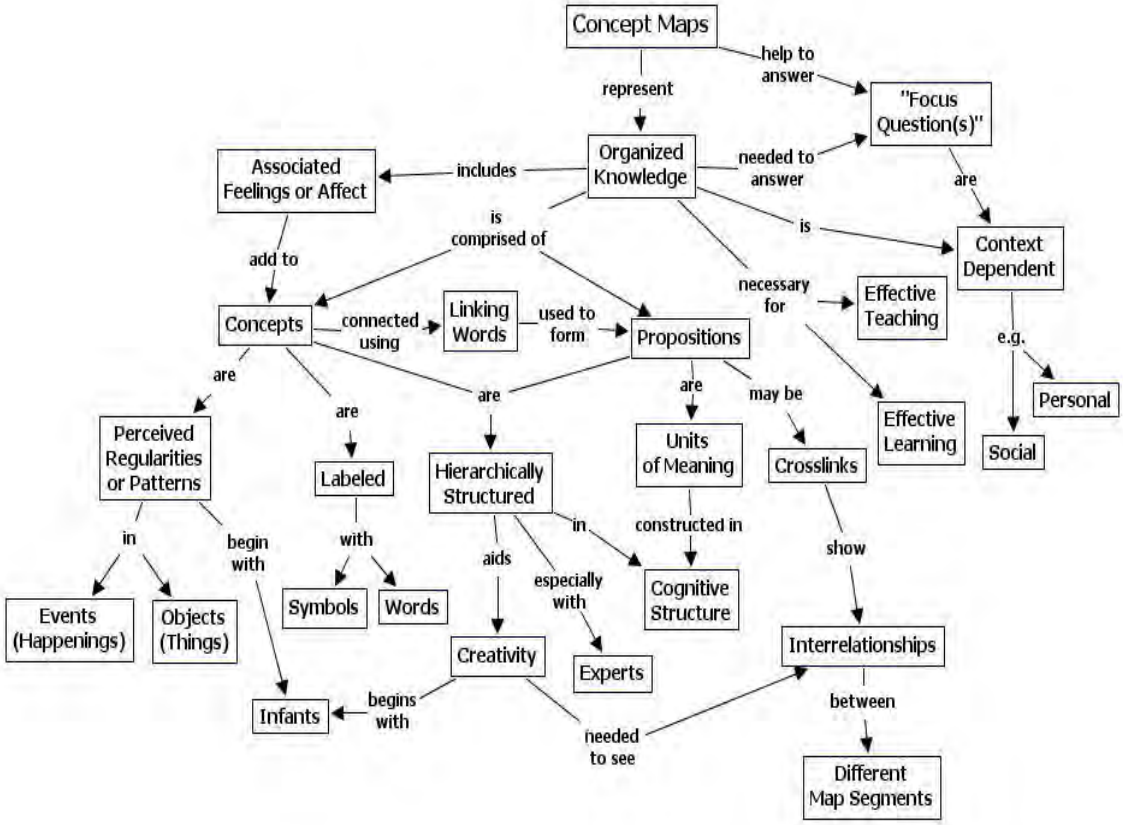

Figure 1. Schematic diagram showing a concept map

Source: Cañas, 2003

Concept map works by providing a visual means of showing connections and relationships between a hierarchy of ideas ranging from the very concrete to the abstract Ajaja (2013).

The importance of concept mapping cannot be over-emphasized. The process of simplifying concepts and arranging them on a page forces the learner to think about what is most important. It helps to clarify one's thought and understanding and makes learning more meaningful. A concept map can be a heuristic device that is a process in which the learner can make discoveries and uncover meanings through trial and error. It helps in the

development of critical thinking skills which is a conscious effort to think about thinking (Ajaja, 2013).

A study conducted by Ajaja (2011) determined the effects of concept mapping as a study skill on student's achievement in Biology. The major findings of this study indicated a significant and consistent improvement in Biology achievement as the period of experience with the use of the method increased. Students who used concept mapping as a study skill retained biological knowledge longer than those who used other methods. All the students interviewed in the concept mapping classroom agreed that concept maps helped them not only in the determination of the relationships among the concepts but also shaped their understanding of the concepts and increased their critical thinking. Jegede, Alaiyemola and Okebukola (1992), comparing the effectiveness of concept maps as teaching strategy in Nigeria, and Ezeudu (1998), examining the effect of concept mapping on students' chemistry achievement in Enugu and Nsukka educational zones, found that students taught with concept mapping significantly performed better on achievement tests than those in the control group. These findings indicate that concept mapping facilitates meaningful learning and understanding of concepts in science. Mensah, Otuka and Ernest (1995), in a similar study in senior secondary schools in Ghana, found that concept mapping can be used as a pre-instructional and post-instructional tool in Biology. Obianor (1997) and Ezeudu (1998) provided two opposing views on how concept mapping affect students of different sexes. Ezeudu (1998), who studied the interaction effect between concept mapping and gender on achievement in Chemistry, found that the male students significantly out-performed the females in the achievement test administered. Obianor (1997) found that there was no

significant difference in achievement between males and females taught with concept mapping. This is consistent with the findings of Ajaja (2013).

The major limitation of concept mapping is that it taps high cognitive ability and a very good mastery of the subject area. Low ability teachers and learners may not be able to draw and use concept maps for teaching and learning. It is not easy to construct, and respondents require training and practice in producing maps. There are also difficulties with the interpretation of concept maps in particular with devising appropriate ways of scoring to enable valid comparisons to be made Ajaja (2013).

2.3.2 Cooperative learning

Cooperative learning is an instructional strategy which organizes students in small groups so that they can work together to maximize their own and each other's learning. Specifically, the cooperative learning approach to instruction is where students are arranged in pairs or small groups to help each other learn assigned material Ajaja (2013). In cooperative learning groups, unlike self-directed inquiry, students gradually take responsibility for each other's learning. Ajaja (2013) identified four basic elements in cooperative learning models. Small groups must be structured for positive interdependence, where students believe that they 'sink' or 'swim' together; there should be face-to-face interactions, individual accountability, and the use of interpersonal and small group skills.

A review of studies on the effects of cooperative learning on students' achievement indicated that cooperative learning gains are not limited to a particular ability level or sex but to all who engage in it Ajaja (2013). Stevens and Slavin (1995) linked cooperative learning to increase in academic achievement of learners at all ability levels. A study

conducted by Ajaja and Eravwoke (2010) reaffirmed the ability of cooperative learning when used as an instructional strategy to bring about significant improvement in students' achievement in school science subjects. The findings of the study indicated that students in cooperative learning group outscored those in the lecture group in an achievement test. However, there was a non-significant difference in achievement scores between male and female students in the cooperative learning group. The findings of the work by Ajaja (2013) also supports this observation.

2.3.3 Learning cycle

The learning cycle is a generic term used to describe any model of scientific inquiry that encourages students to develop their own understanding of a scientific concept, explore and deepen that understanding and then apply the concept to new situations (Walbert, 2003). The learning cycle is an established planning method in science education and is consistent with contemporary theories about how individuals learn (Lorsbach & Tobin 1997). It is useful in creating opportunities to learn science (Ajaja, 2013). There are different models of the learning cycles, popular among these models are the three phase model, four phase model and the five phase model.

The first three phase model of the learning cycle consist of exploration, invention and discovery. A fifth phase, called evaluation, was incorporated into an elementary science program developed by the Biological Science Curriculum Study (Biological Science Curriculum Study, 1992) and this gave birth to the model called 5E learning cycle. The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engage, Explore, Explain, Elaborate, and Evaluate.

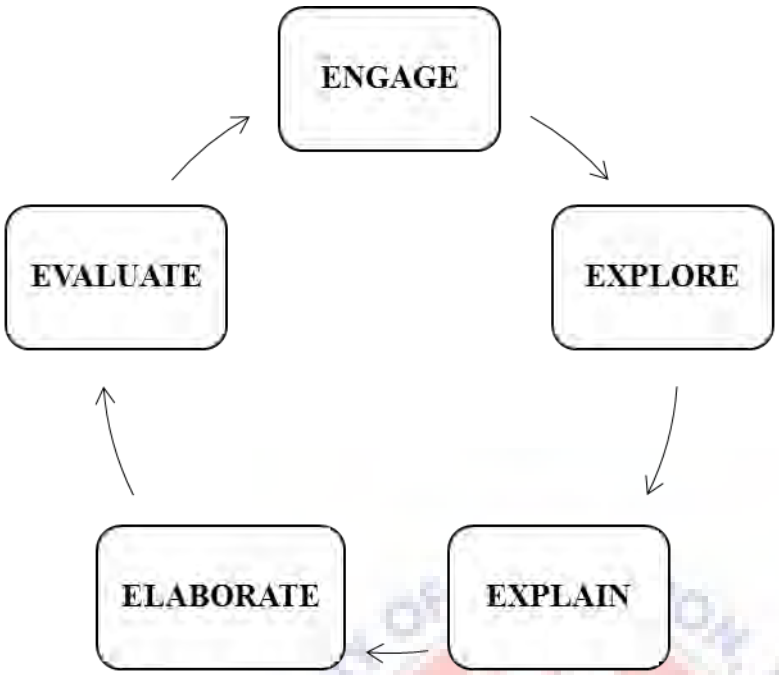

Figure 2. Schematic diagram showing a 5E Learning cycle

Source: Tuna & Kaçar, 2013

Most empirical studies on the effectiveness of learning cycle when used as an instructional strategy found significant improvement in students' achievement, retention, attitude and correction of misconceptions. Nuhoglu and Yalcin (2006) specifically emphasized that learning cycle make knowledge long lasting and that students become more capable of applying their knowledge in other areas outside the original context. The work of Ajaja (2013) confirmed this assertion when he found out that 5E learning cycle resulted in a high retention rate (90.7%) as compared to that of concept mapping and cooperative learning, that is 81.11% and 88.44% respectively.

Inadequate or lack of practical work during biology lessons could be a hindrance to students' understanding of new biological concepts. Practical work brings reality into the classroom and serves as a link between real life and theory, a situation that greatly aids

pupils' understanding of the abstract terms. Experiments promote relevant basic skills and competences that pupils need in order to comprehend complex concepts. It is equally observed that scarcity of appropriate equipment is yet another setback. Much as the pupils and their teachers would want to engage in practical work as a way of simplifying the concepts that pupils would otherwise find incomprehensible, some schools just have no relevant resources that teachers need to teach the challenging topics in biology. Some scholars have argued that even though resources for teaching practical work could be available, some pupils are simply poor in performing scientific experiments; their practical skills are quite poor especially with regard to handling of instruments or apparatus and making correct observations which, in essence, affects the interplay of experiments, observations and theoretical inferences (Woodley, 2009).

2.4 Theoretical framework

This study is built on the theory of constructivism as explained by Jean Baptist Piaget and Vygotsky. This theory is normally attributed to Jean Piaget who explained the mechanism by which knowledge is internalized by students. Constructivism is a theory of learning that is developed from the principle of children's thinking. It states that children learn through adaptation. Children are not passive in knowledge, but active at making meaning, testing out theories, and trying to make sense out of the world and themselves. Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own "rules" and "mental models," which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences.

According to Piaget, through the process of accommodation and assimilation, individuals construct their own knowledge from their experiences and during assimilation they incorporate the new experiences without changing the already existing frame work. The theory of constructivism holds that:

- Learning outcomes depend not only on the learning environment but also on the knowledge of the learner;
- Learning involves constructing meaning;
- Construction of a meaning is influenced to a large extent by existing knowledge;
- The meanings constructed are evaluated and can be accepted or rejected;
- There are patterns in the types of meanings pupils construct due to shared experiences with the physical world and through their natural language (Bennett, 2002; Vygotsky, 1978).

Piaget explores four sequential stages of the psychological development of the young learner and believes teachers should be cognizant of these stages. During the Sensory-motor Stage, (before the age of 2) sensory experiences and motor activities dominate. Intelligence is intuitive in nature and knowledge; it is acquired through mental representation during the Preoperational Stage (from age 2 to age 7). At the Concrete Operational Stage (from age 7 to age 11), intelligence is logical, conserved, and dependent on concrete references. The Formal Operational Stage (after 11 years of age) is the stage when abstract thinking starts and the learner starts thinking about probabilities, associations, and analogies.

Lev Vygotsky, known for his theory of social constructivism, believes that learning and development is a collaborative activity and that children are cognitively developed in the context of socialization and education. The perceptual, attention, and memory capacities of children are transformed by vital cognitive tools provided by culture, such as history, social context, traditions, language, and religion. For learning to occur, the child first makes contact with the social environment on an interpersonal level and then internalizes this experience. The earlier notions and new experiences influence the child, who then constructs new ideas. For Vygotsky, the zone of proximal development, that is "the distance between the actual development of a child as determined by the independent problem solving, and the level of potential development as determined through problem solving under adult guidance or in collaboration with more peers (Vygotsky, 1978)".

This theoretical framework is appropriate because it clearly explains why students would fail to understand the difficult biological concepts as their complexity bears no relationship with the student's existing knowledge. Construction of meaning depends upon the already existing knowledge in the learner and their experience with the learning environment. The complex biological terms and concepts such as genetics, nervous system and other related concepts would be deemed as not being part of the learning environment with which the pupils have had experience. There is considerable research evidence to support the notion that children construct their own explanations for scientific phenomena and that such explanations may differ from the accepted scientific explanations. Areas where this has been demonstrated to be the case include: photosynthesis, respiration, biological classification, evolution (Ozer, 2004).

In Piagetian classroom a variety of activities must be provided to challenge students to accept individual differences, increase their readiness to learn, discover new ideas, and construct their own knowledge. Concrete learning experiences, such as drawing, drama, model building and field trips that involve hands-on opportunities to see, hear, touch, taste, and smell are essential.

A Vygotskian classroom emphasizes creating one's own concepts and making knowledge one's property; this requires that school learning takes place in a meaningful context, alongside the learning that occurs in the real world. As seen earlier in the Piagetian classroom, this model also promotes the active participation and collaboration of distinctive learners. The Vygotskian classroom stresses assisted discovery through teacher-student and student-student interaction. Some of the cognitive strategies that group members bring into the classroom are questioning, predicting, summarizing, and clarifying.

Figure 3 shows how an individual who is exposed to a learning experience constructs his or her ideas and meaning which undergo restructuring, clarification and evaluation before accommodation of the new ideas.

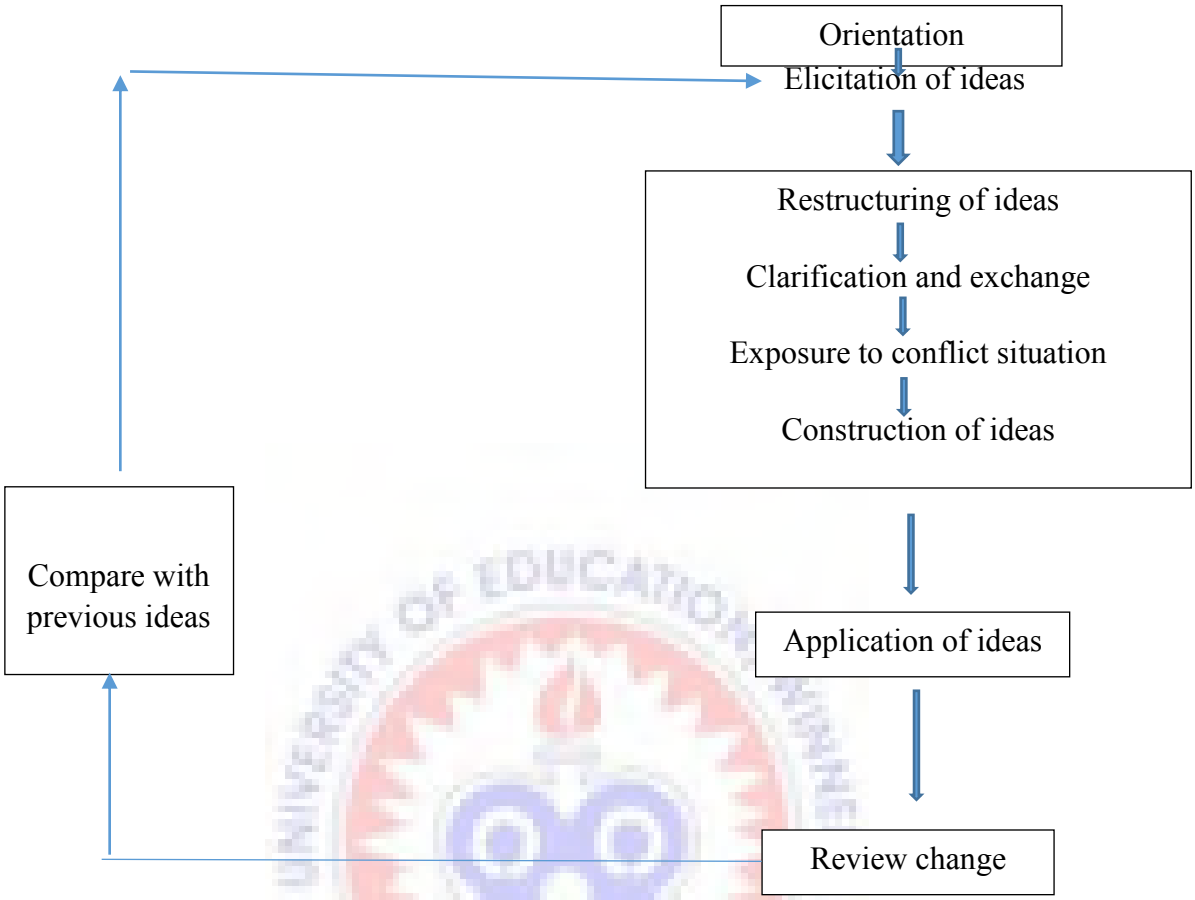

Figure 3. Processes of knowledge construction and accommodation

Source: Bennett, 2002

The theory suggests that as long as some topics remain new, complex in terms of terminologies, and students lack prior knowledge, they will certainly fail to construct meaning and make sense out of their learning experiences. This is largely due to the fact that construction of knowledge, ideas or meaning largely depends upon the already existing knowledge in the student known as schemas. It is therefore, as Bennett (2002) puts it, important for the pupils to be exposed to an environment of elicitation of ideas in the biological topics that have been demonstrated to cause difficulties for the pupils because they hold ideas or patterns of ideas which differ from the accepted scientific explanations.

2.5 Conclusions

In conclusion, literature showed that there are several gaps that cause students to fail to understand some topics in biology. These gaps include: language and vocabulary used, students' mathematical background, students' attitude, teachers' academic and professional qualification, gender effect, learning styles and teaching strategies. The review of the literature revealed that there is a correlation between the gaps stated above and the learning of biological concepts. This study is undertaken to bridge some of the gaps.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter introduces the methodology employed in the study. It deals with the type of research design, population, sample and sampling procedures, instruments, data collection procedure, and data analysis.

3.1 Research design

The study is a descriptive survey and mainly qualitative, however, the study employed some quantitative elements. "Descriptive research is concerned with conditions or relationships that exist; practices that prevail; beliefs, points of views, or attitudes that are held; processes that are going on; effects that are being felt; or trends that are developing. Descriptive research is also concerned with how what is or what exists is related to some preceding event that has influenced or affected a present condition or event" (Cohen, Manion & Morrison, 2007:119, 206). Such studies look at individuals, groups, institutions, methods and materials in order to describe, compare, contrast, classify, analyse and interpret the entities and the events that constitute their various fields of inquiry. Typically, surveys gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events.

3.2 Population and Sample size

The study was limited to all biology students in all Senior High Schools (S.H.S.s) in the Mampong and Ejura-Sekyedumase Municipal Assemblies in the Ashanti Region of Ghana. There are six (6) Senior High School in the assemblies, out of which only one is private. These include: St Monica's S.H.S., St Joseph's Seminary, Amaniampong S.H.S., Odiko Boatemaa S.H.S. (private), Sekyedumase S.H.S. and Ejuraman Anglican S.H.S. Overall, a total of 312 research subjects were selected. The choice of these schools was based on the fact that all the schools give a real representation of the category of senior high schools. St Monica's S.H.S. is in the category of Option 3 which are deemed as first class or class A schools, Amanianpong S.H.S., Sekyedumase S.H.S. and Ejuraman Anglican S.H.S. are all in the category of Option 1, whiles Oduko Boatemaa S.H.S. is in the category of Option 5 which are classified as private schools (Register of programmes and courses for Public and Private S.H.S., Technical and Vocational Institutes, 2014).

3.3 Sample and Sampling procedure

The sample consisted of 12 biology tutors (2 from each school) and 300 second year biology students (50 from each school). This study employed purposive sampling technique. Purposive sampling technique is used when the researcher wants to study a particular group of people or research subjects. Cohen *et. al*. (2007) agree to this and assert that in purposive sampling, researchers handpick the cases to be included in the sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought. In this way, they build up a sample that is satisfactory to their specific needs.

3.4 Research instruments for data collection

Data was collected by questionnaires and planned interviews.

3.4.1 Questionnaire

A set of questionnaire and planned interview were the main research instruments used to collect data for the study. Two sets of questionnaires were designed and administered to biology students and biology teachers after they have been proof-read by the supervisor. This method of collecting data was employed because it is free from the bias of the researcher; answers are in respondents' own words, large samples can be made use of and thus the results can be made more dependable and reliable (Kothari, 2004).

3.4.2 Interview schedule

The views of experts in the field were also sought after through planned interviews. The interview method of data collection involved presentation of oral-verbal stimuli and reply in terms of oral-verbal responses, specifically, the personal interview method which requires a person known as the interviewer asking questions generally in a face-to-face contact to the other person or persons also known as the interviewee (Kothari, 2004). The personal interview method is useful because the interviewer by his own skill can overcome the resistance, if any, of the respondents; the interview method yields an almost perfect sample of the general population, and samples can be controlled more effectively as there arises no difficulty of the missing returns; non-response generally remains very low (Kothari, 2004).

3.4.3 Teaching activity

Some of the concepts identified by the students as difficult were addressed using concept mapping, cooperative learning and learning cycle after which their effectiveness were evaluated by engaging students in some prepared test items.

3.4.3.1 Concept mapping

Concepts within a particular topic would be presented graphically using a concept map. In a concept map, concepts were represented in circles or boxes, and relationships between them were indicated by connecting lines that link them together. The concepts were represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered. Also important and characteristic of the concept map was the inclusion of "crosslinks." These reveal the relationships between or among concepts in different regions or domains within the concept map. They show how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. Finally, specific examples of events or objects were included. These can help to clarify the meaning of a given concept. These are not included in ovals or boxes, since they are specific events or objects and do not represent concepts.

The use of a concept map to illustrate Cellular or Tissue respiration is shown in Figure 4.

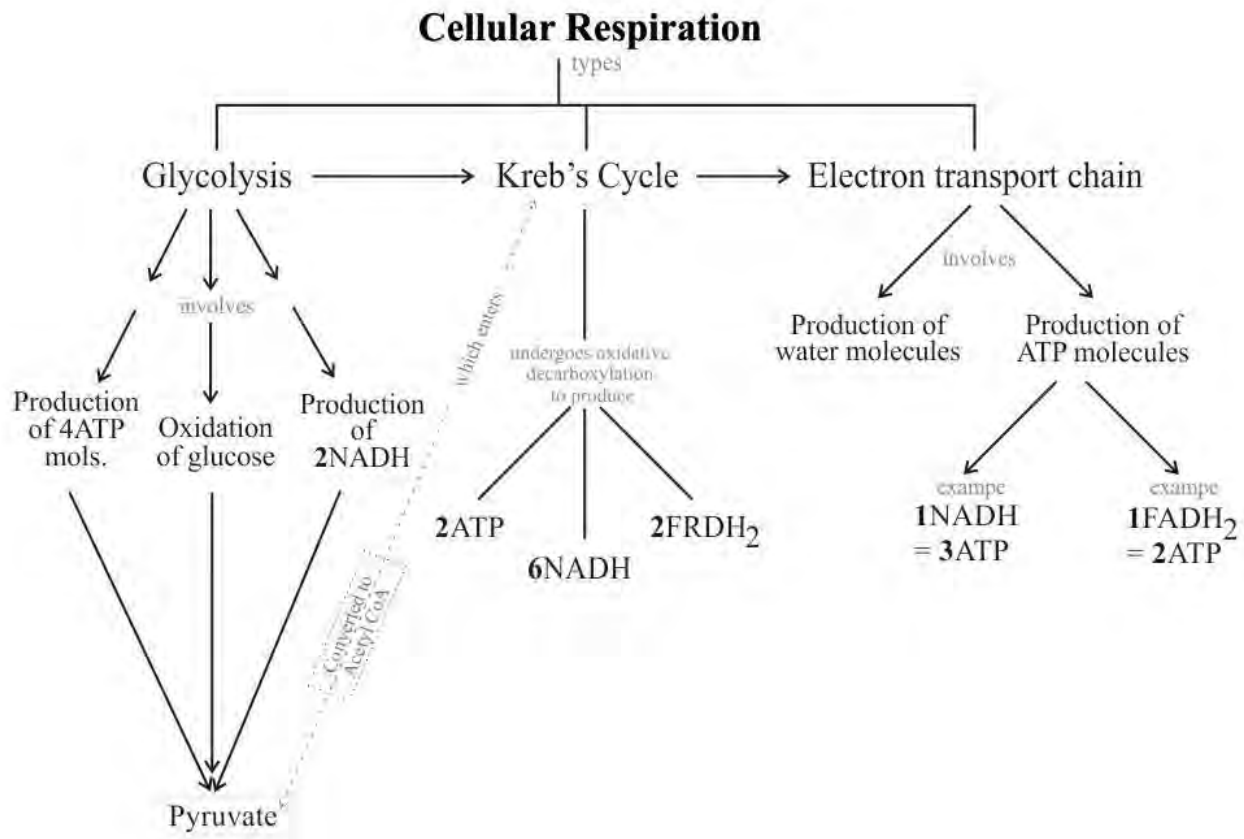

Figure 4. A concept map showing tissue or cellular respiration

Tissue or cellular respiration involves three main processes: glycolysis, the Kreb's cycle and the electron transport chain (ETC). Glycolysis involves the oxidation of a glucose molecule to pyruvate or pyruvic acid (3-C compound). The Kreb's cycle also involves the production of energy-rich molecules (NADH and $FADH_2$) which can then be used to produce ATP (Adenosine triphosphate) in the mitochondrion of the cell. The electron transport chain (ETC) is the final stage of tissue respiration and involves the dissipation of the energy in NADH and $FADH_2$ to produce ATP molecules.

ENERGY YIELD

Glycolysis produced 2 ATP and 2 NADH molecules and that the conversion of pyruvate to acetyl coA also produced 2 more NADH molecules. Six (6) molecules of NADH and two molecules of $FADH_2$ as well as 2 ATP's were produced from the Kreb's cycle. Thus:

10 NADH x 3 ATP = 30 ATP

2 FADH2 x 2 ATP = 4 ATP

Glycolysis = 2 ATP

Kreb's cycle = 2 ATP

Total 38 ATP

3.4.3.2 The learning cycle

In the 5E learning cycle, students were taken through five phases of learning that are easily described using words that begin with the letter E: Engage, Explore, Explain, Elaborate, and Evaluate.

The *Engage* lesson was used to pique students' curiosity and arouse their interest, determine students' current understanding about scientific inquiry, invite students to raise their own questions about the process of scientific inquiry, encourage students to compare their ideas with those of others, and enable teachers to assess what students do or do not understand about the stated outcomes of the lesson.

The *Explore* lesson also helped students to interact with materials and ideas through classroom and small-group discussions, consider different ways to solve a problem or frame a question, acquire a common set of experiences so that they can compare results and ideas with their classmates, observe, describe, record, compare, and share their ideas and

experiences and express their developing understanding of testable questions and scientific inquiry.

The *Explain* lesson was to encourage students to explain concepts and ideas (in their own words) about a potential health problem, listen to and compare the explanations of others with their own, become involved in student-to-student discourse in which they explain their thinking to others and debate their ideas, revise their ideas, record their ideas and current understanding, use labels, terminology, and formal language and compare their current thinking with what they previously thought.

In the *Elaborate* lesson, students made conceptual connections between new and former experiences, connect ideas, solve problems, and apply their understanding to a new situation, use scientific terms and descriptions, draw reasonable conclusions from evidence and data, deepen their understanding of concepts and processes and communicate their understanding to others.

Finally, the *Evaluate* lesson provided students the opportunity to demonstrate what they understand about scientific inquiry and how well they can apply their knowledge to carry out their own scientific investigation and to evaluate an investigation carried out by a classmate, share their current thinking with others, assess their own progress by comparing their current understanding with their prior knowledge and ask questions that take them deeper into a concept.

As an illustration is the use of 5E learning cycle to explain the Calvin cycle of photosynthesis:

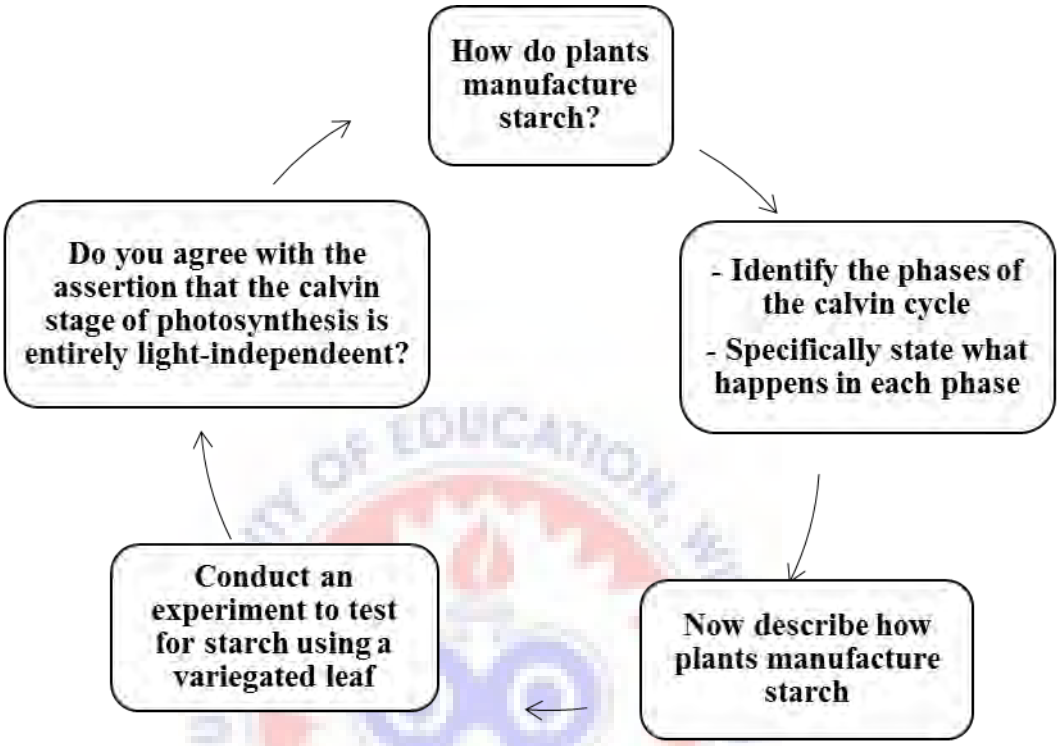

Figure 5. A 5E learning cycle showing the Calvin cycle of photosynthesis

3.4.3.3 Cooperative learning

In the cooperative learning, students were put into different groups. One group called the jigsaw which comprised of a group of five in which each group member was assigned some unique material to learn and then to teach to his group members. To help in the learning, students across the class working on the same sub-section got together to decide what is important and how to teach it.

Another group called the Think-Pair-Share involved a three step cooperative structure. During the first step, individual student was made to think silently about a question posed by the instructor, they then pair up during the second step and exchange thoughts. In the third step, the pairs share their responses with other pairs, other teams, or the entire group.

In the Three-Step Interview, each team member chooses another member to be a partner. During the first step individuals interview their partners by asking clarifying questions. During the second step partners reverse the roles. For the final step, members share their partner's response with the team.

In the Round Robin Brainstorming, the class was divided into small groups (4 to 6) with one person appointed as the recorder. A question was then posed with many answers and students were given time to think about answers. After the "think time," members of the team share responses with one another round robin style. The recorder then writes down the answers of the group members. The person next to the recorder starts and each person in the group in order gives an answer until time is called.

The Three-minute review allowed teachers to pause at any time during a lecture or discussion and give teams three minutes to review what has been said, ask clarifying questions or answer questions.

In the Team Pair Solo, students tried their hands on problems first as a team, then with a partner, and finally on their own in order to motivate students to tackle and succeed at problems which initially are beyond their ability.

3.5 Pre-test of instruments

The instruments were pre-tested using the third year students of Sekyedumase senior high school and St. Monica's senior high school in order to ascertain their validity and reliability. Cohen *et. al*. (2007:152) assert that if a piece of research is invalid then it is worthless. In view of this, the validity or trustworthiness of findings should be of outmost importance in every research. Data from different classes was triangulated to prove their validity. As observed by Quinn and Cochran (2002:28), if triangulated data coincide, this

strengthens their validity and reliability. In this study, the instruments were tested on biology students and teachers from both schools.

3.6 Data collection procedure

The researcher obtained a letter of introduction from the Coordinator for graduate school, Department of Science Education, University of Education, Winneba (UEW), after which permission was sought from the headmasters and mistresses of the schools with the introductory letter to allow the researcher use the intended subjects for the research. Thereafter the objectives of the study were made known to the respondents after permission has been granted. The researcher then introduced himself to the respondents and assured them of confidentiality. The questionnaires were administered by the researcher himself, after which they were collected. This was then followed immediately with an interview section with biology tutors.

3.7 Procedure for data collection/Ethical consideration

Researchers have responsibilities to their research participants, their colleagues, and the people to whom the findings are presented. Quinn and Cochran (2002:36) identified four principles as far as ethical issues are concerned. These include; autonomy, that is respect for the rights of the individual, beneficence – doing good, non-maleficence – not doing harm, justice – particularly equity. Two key ethical issues should be considered in any study or research; consent and confidentiality (Quinn & Cochran, 2002:36). The researcher ensured that participation by staff and students was voluntary, and that the consent forms were given to the respondents to sign before taking part in the data collection process. Also, in order to promote and enhance confidentiality, respondents were asked not to write

their names on the form. Respondents remained anonymous, and were assured that the data obtained from them would not be disclosed to any other person.

3.8 Data Analysis

Analysis of a data refers to techniques the investigator employs to extract the information to enable a summary description of subjects studied (Nwana, 1992). When data had been collected, they were edited and checked for accuracy and authenticity. For example, the researcher made follow-ups on informants to clarify some contradictions and gaps in the questionnaires or interviews. Data from questionnaires was compiled, sorted, edited, classified and coded into a coding sheet and analyzed. Quantitative data captured in this study was analysed by making use of the 2016 version of Excel. This analysis made use of descriptive statistics which involves frequency tables, charts and percentages. Finally, the researcher made interpretations of the questionnaire and interview responses.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents findings on topics in Biology perceived as difficult for Senior High School students. The results have been presented in tables while those which were not quantified were described. The data were categorized into preliminary and main data. The preliminary data were designed to unearth the background information of the respondents in relation to age, academic and professional qualification and teaching experience. The main data of the analysis took into consideration the three research questions formulated for the study.

4.1 Teachers' experience

The study sought information on the teachers' experience because of its bearing on the students' performance in biology. The data obtained is presented in Figure 6.

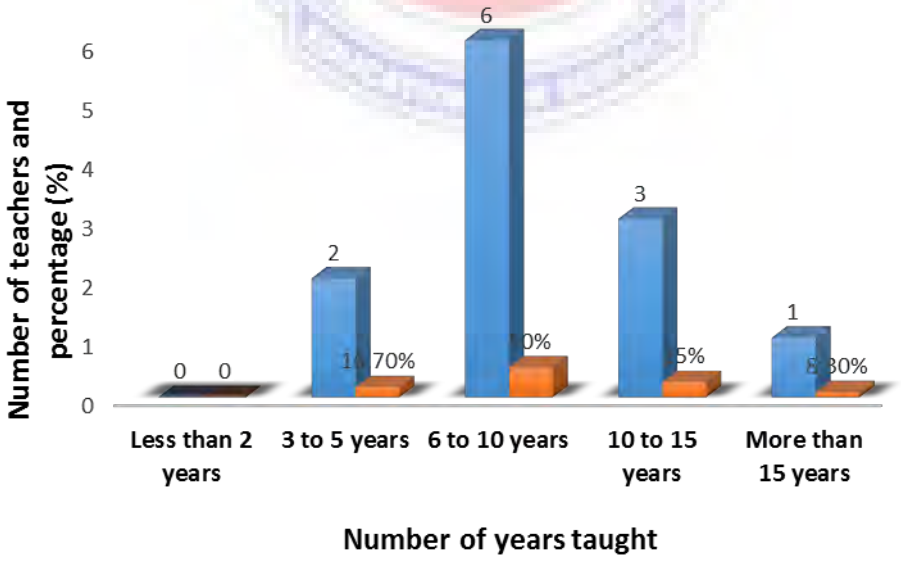

Figure 6. Teachers' years of experience

From Figure 6, it is shown that out of the 12 teachers who responded, 6 of them, constituting 50.0% have taught for 6 to 10 years while 3 teachers representing 25.0% indicated that they had worked for 10 to 15 years. However, as low as 1 (8.3%) of the teachers reported that they had taught biology for more than 15 years. This implies that majority of the teachers have not taught biology for more than 15 years.

4.2 Teachers' qualifications

The study further sought to find the highest professional qualification teachers were holding in the schools. Presented in Figure 7 are the responses gathered.

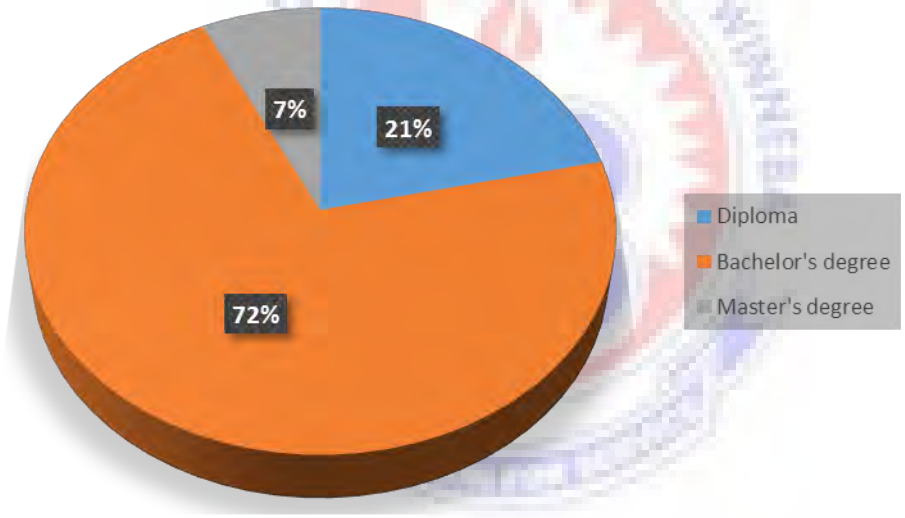

Figure 7. Qualification of teachers in the selected six senior high schools

From Figure 7, it is indicated that more than half of the teachers (10) representing 72% had a bachelor's degree, while only 3 (21%) reported that they possessed a Diploma in Education. Only 1 respondent indicated that he/she had a Master's degree. This means that although the teachers are qualified to teach biology at the senior high level, most of the teachers have not upgraded themselves.

4.3 Students' profile

The researcher tried to find information on the age distribution of students offering biology in the six selected senior high schools in the two municipalities. The responses are presented in Figure 8.

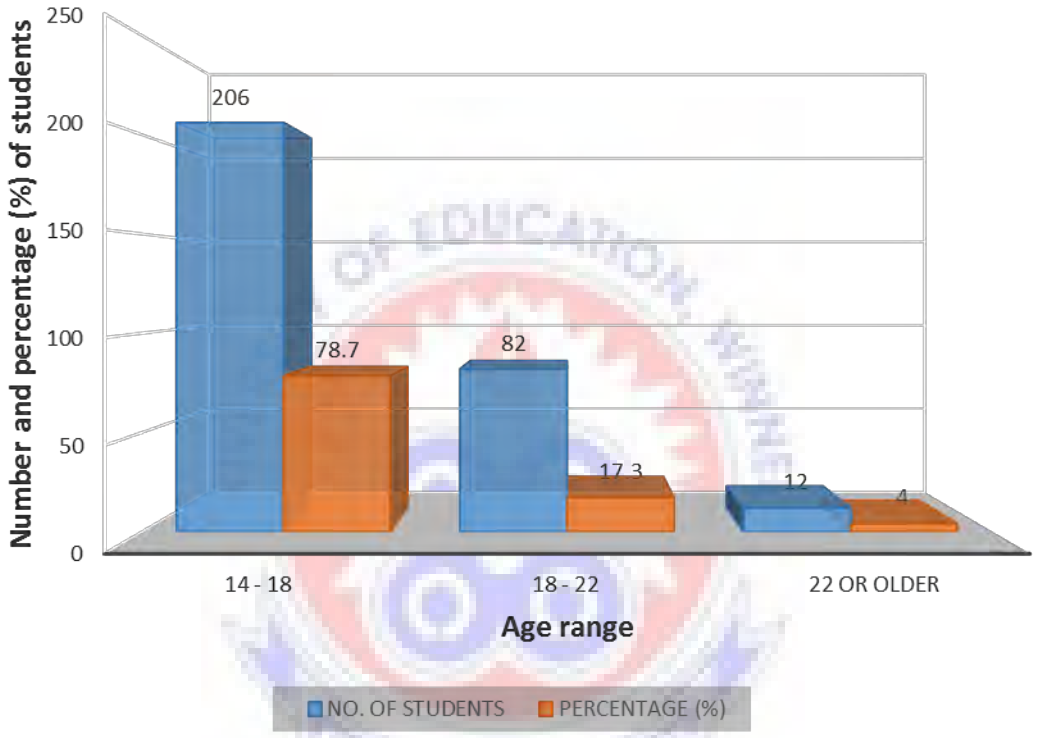

Figure 8. Age distribution of students

Figure 8 clearly shows that, 206 students representing 78.7% who form the majority fell under the age bracket of 14 to18 years, while 82 out of 300 students representing 17.3% were between the ages of 18 to 22. A small number of students (12) representing 4.0% fell in the age bracket of 22 or older. This implies that there was a relatively small proportion of adult students in the schools under study.

4.4 Analysis of the Main Data

The presentation of the main data was done in relation with the three research questions which focused on the biology topics perceived to be difficult, reasons that are attributed to these difficulties and teaching and learning strategies that can be employed to lessen students' learning difficulties.

Research Question 1: What topics in biology are perceived to be difficult to learn by Senior High School students?

This aspect of the research question sought to survey data relating to topics in biology students find difficult to learn. The data gathered is presented in Figure 9.

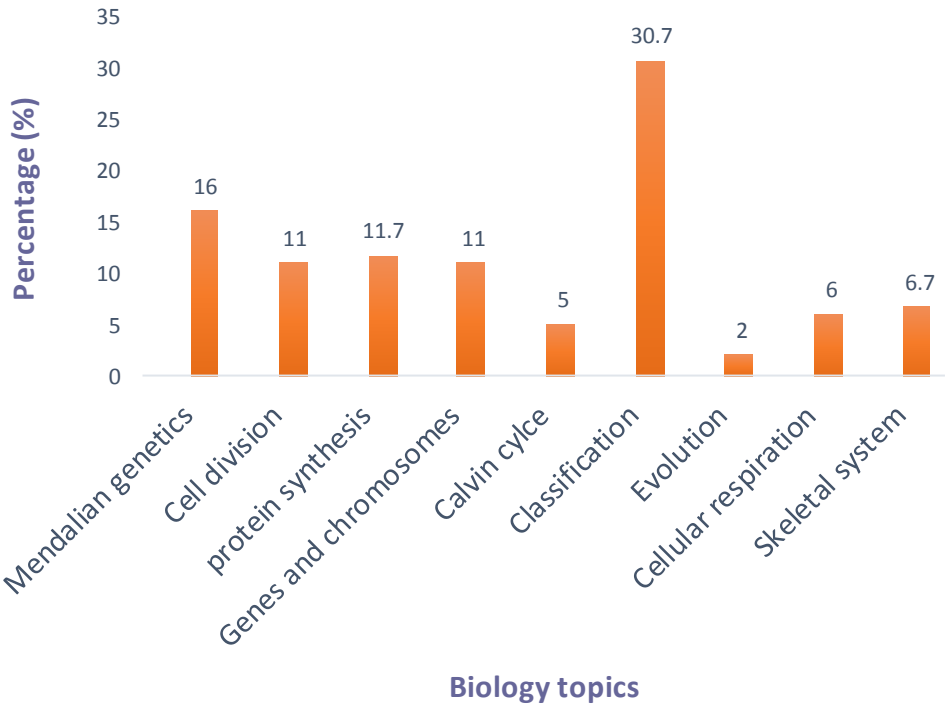

Figure 9. Topics in biology perceived to be difficult for students to learn

As shown in Figure 9, a significant majority of the students (92) representing 30.7% indicated that classification was the most difficult topic, while 48 out of the 300 respondents claimed genetics as the most difficult topic. Again, 35 (11.7%) of the respondents indicated that protein synthesis was the most difficult topic. Cell division and genes and chromosomes were selected by 33 of the students representing 11.0% as the most difficult topics. Only 6 of the respondents representing 2.0% indicated that Evolution was the most difficult topic. This implies that students had difficulties when learning some biology topics.

On the same issue, teachers were asked to indicate the topics they perceived their students may find them difficult to learn. A combination of questionnaire and interview were used to elicit teachers' response. This was done to corroborate the responses drew from the students. Presented in Figure 10 is the data obtained.

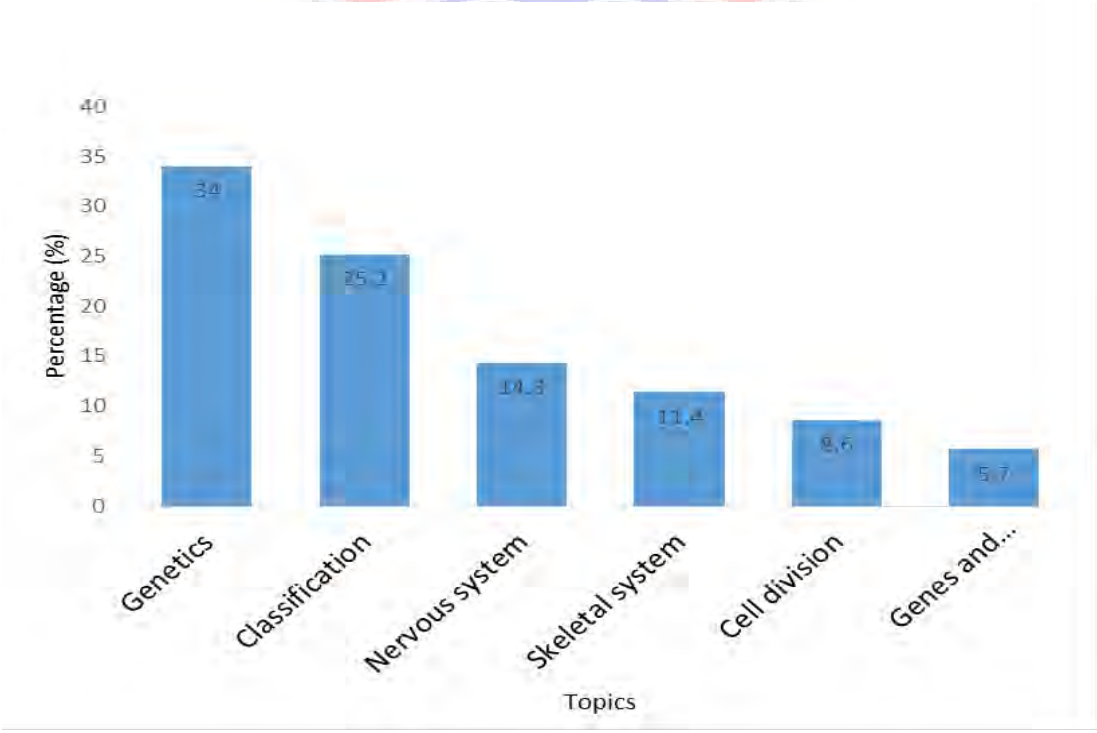

Figure 10. Topics teachers thought students perceived to be difficult

As shown in Figure 10, 4 of the teachers representing 34.0% indicated that they perceive genetics as the most difficult topic, followed by classification with a percentage of 25.2.

Only 1 respondent constituting 5.7% perceived genes and chromosomes as the most difficult topic in biology for students to learn. This is in contrast with the views of the students from Figure 9 which indicates that classification is the most difficult topic in biology, followed by genetics.

Research Question 2: What reasons do students attribute to these difficult topics?

The researcher set out to gather data to ascertain the reasons students saw these topics as difficult to learn. Presented in Table 1 are responses of participants.

Table 1: Students' reasons for the most difficult topics in biology

Topic	Reasons	Frequency	Percentage (%)
Mendalian genetics	Terms used complex	8	16.0
	Calculations involved difficult	19	
	It is too abstract	6	
	Topic too broad	5	
	Genetic diagrams difficult	10	
Classification	Topic is too broad	25	30.7
	It is too abstract	12	
	Vocabulary too difficult and easy to forget	48	
	Poor teachers' explanation	2	
	Inadequate biological drawing	5	
Calvin cycle	Too abstract	3	5.0
	Poor teachers' explanation	5	
	Terms too difficult to pronounce	7	

Skeletal system	Poor teachers' explanation	5	6.7
	Teachers' failure to use charts or TLM's	12	
	Terms too complex	3	
Cellular respiration		9	6.0
	Long cyclical equations make it too difficult	4	
	Topic too abstract	5	
	Poor teachers' explanation		
Evolution (Theories of evolution)			
	Topic is too abstract	4	2.0
	Poor teachers' explanation	1	
	Topic too broad	1	

From Table 1, it is clear that 92 out of 300 students representing 30.7% claimed that the reason why classification is difficult to learn was due to teachers' failure to cite practical and familiar examples, names and terms used are too complex and easy to forget. Again, the topic is too broad, and there is inadequate biological diagrams to support learning. Another 48 (16.0%) of the students who indicated that genetics was difficult provided the following reasons: teachers do not give detailed explanations, names and the terms used are complex. Again, genetic diagrams and calculations are difficult for the students to understand. Twenty of the students representing 6.7% who mentioned skeletal system as difficult alleged that because the topic was bulky, and that lack of teaching and learning resources in schools compounded the situation, while 6.0% of the students numbering 18 said that cellular respiration was difficult because the topic involved long cyclical equations and teachers gave little explanation of concepts. Another 15 (5.0%) of students

claimed that Calvin cycle of photosynthesis was difficult because it is characterized by the complexity of names of chemical compounds and also teachers gave little explanation. As low as 6 students representing 2.0% pointed out that evolution was difficult for the reason that the topic was too broad and abstract. Some were also of the view that the theories in the topic contradicted their religious doctrines and this discouraged its study. The results showed that the majority of the respondents cited difficult terms, abstract nature and poor teachers 'explanation as being the main contributors to them finding the topics difficult.

On the same question, teachers were asked to suggest reasons to why some topics were perceived to be difficult for students to learn. A combination of questionnaire and interview were used to elicit teachers' response. This was done to confirm the responses elicited from the students.

A total of 12 biology teachers responded to the questionnaires. The data obtained is presented in Table 2.

Table 2: Teachers' reasons for the topics students perceived as difficult

Topic	Reasons	Frequency	Percentage (%)
Mendalian genetics	Terms are too technical and complex	3	28.0
	Calculations involved difficult	2	
	It is too abstract	1	
	Genetic diagrams difficult	1	
Classification	Topic is too broad	1	20.0
	It is too abstract	1	
	Vocabulary too difficult and easy to forget	2	
	Lack of TLM's to support lesson	1	
Cell division (Mitosis and Meiosis)	Topic is too abstract	2	16.0
	Lack of diagrams to support lesson	1	
	Process is too complex	1	
Genes and chromosomes	Too abstract	1	8.0
	Application of concept difficult	1	
Nervous system	Terms used too difficult	2	16.0
	Too broad and abstract	2	
Skeletal system	Lack of TLM's to support lesson	2	16.0
	Complex terminologies	2	

From Table 2, it can be seen that, a good majority of the teachers (7) representing 28.0% showed that genetics was the most difficult because it involves calculations, complex genetic diagrams and terminologies. Five respondents representing 20.0% also held that classification was difficult because of the following reasons: it is too broad and abstract, it contains complex vocabulary which can easily be forgotten, and there is also lack of teaching and learning resources to support lesson. The table also shows that 4 of the respondents (16.0%) mentioned cell division (mitosis and meiosis) and said that the topic was too abstract, the processes involved in the cell cycle are too complex and lack of models to support teaching and learning as the reasons for the difficulty they experienced when learning. Again, 6.0% of respondents numbering 4 also mentioned that the nervous system and the skeletal system were difficult. According to them, the topics were too broad, terminologies are difficult and the process of impulse conduction is too difficult to understand by students, coupled with the fact that there were no models to support teaching and learning. As low of 2 respondents representing 8.0% named genes and chromosomes as difficult because it is too complex and that the application of principles are complex for students to comprehend.

Students' Challenges when learning difficult topics in biology

Questionnaire item (c) of Appendix D and interview question 5 of Appendix G (what challenges do you face when learning these difficult topics?) were set to identify the various challenges students face when learning these difficult topics in biology. The data obtained is presented in Table 3.

Table 3. Students' specific challenges when learning difficult topics in biology

Students' response	Frequency	Percentage (%)
Topic too abstract	100	33.3
Topic too broad	16	5.3
Teachers' failure to use TLM's	38	12.7
No practical conducted	45	15.0
Complex terms or vocabulary	70	23.3
Unclear explanation	31	10.3
TOTAL	**300**	**100**

From Table 3, a good majority of the students numbering 100 which represents 33.3% claimed that their learning difficulties were as a result of the abstract nature of the topics, while 70 (23.3%) of the students attributed it to the complex terms or vocabulary used. As low as 16 of the respondents representing 5.3% said that the broad nature of the topics contributed to their learning difficulties. Presented in Figure 11 is a summary of these challenges.

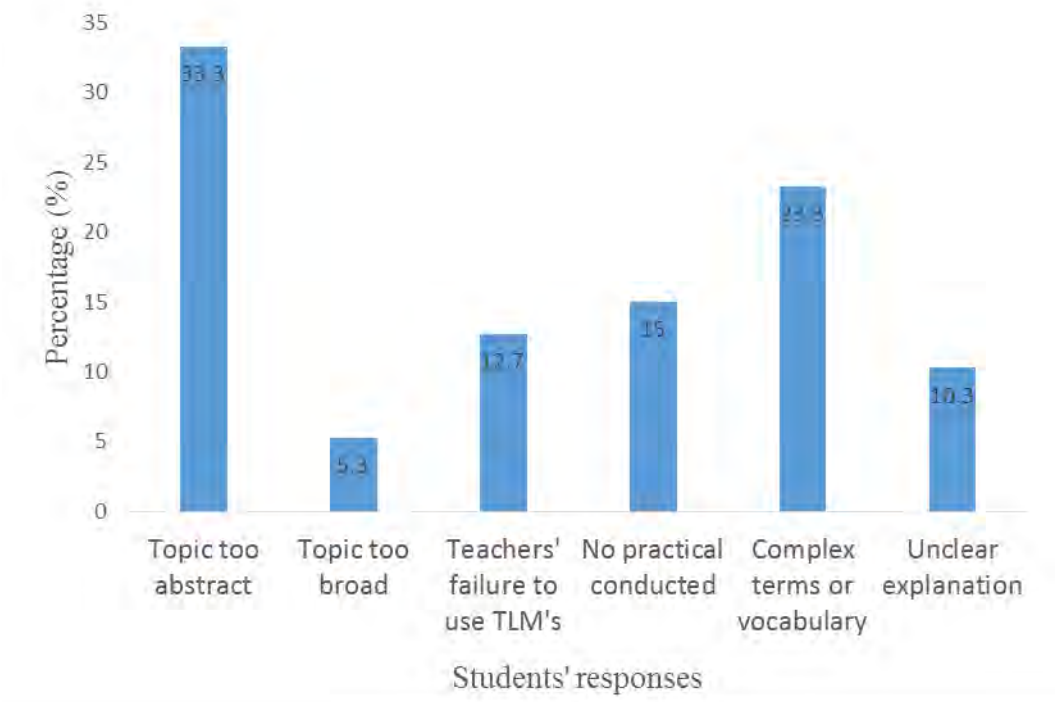

Figure 11. Students' challenges when learning difficult topics in biology

On the same observation, teachers were asked to offer their challenges when teaching these topics. A combination of questionnaire and interview were used to solicit for teachers' response. This was done to compare to the responses obtained from the students. Data obtained is represented in Figure 12.

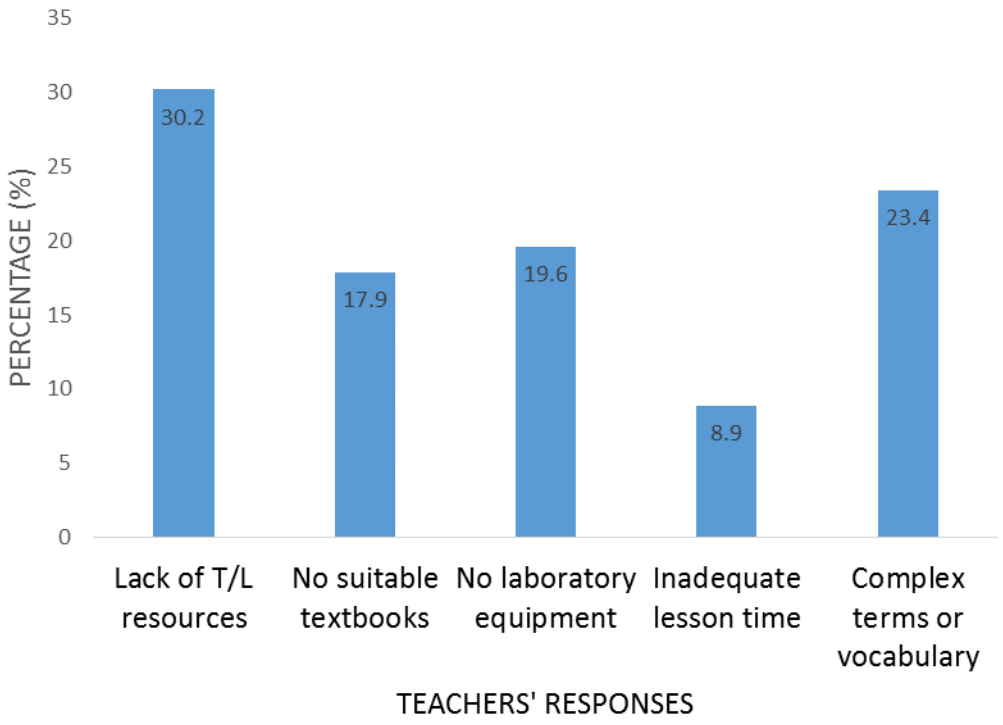

Figure 12. Challenges teachers face when teaching topics perceived as most difficult

According to Figure 12, one-third of the biology teachers numbering 4 with a percentage of 30.2% cited lack of suitable teaching and learning (T/L) resources as the biggest challenge confronting them in biology teaching. Another 2 (19.6%) of the teachers stated that inadequate laboratory equipment and apparatus hinders the conduction practical work. Only a small proportion of the teachers (1) representing 8.9% said that inadequate lesson time posed a challenge to them. This implies that both biology teachers and students face certain challenges in the teaching and learning of biology and therefore require immediate attention to alleviate them.

Research Question 3: What possible teaching and learning strategies would address students' learning difficulties to improve their performance of the topics perceived as difficult?

The findings on this theme were obtained from both questionnaire item (d) of Appendix D and interview item 6 of Appendix G (suggest ways you would want your teacher to help you learn better these difficult topics). The study sought information on the strategies that could be used to lessen students' learning difficulties. The data obtained is presented in Table 4.

Table 4: Students' ideas about how teachers could help them learn the difficult topics

Students' response	Frequency	Percentage (%)
Clear and good teachers' explanation	38	12.7
Use of practical and familiar examples	55	18.3
Teacher to use scientific terms often	22	7.3
Teacher to use teaching and learning (T/L) resources plus ICT	87	29.0
Conduct practical in lessons	72	24.0
Teacher to revise difficult topics	16	5.3
Teacher to give group projects	20	6.7
Total	**300**	**100**

From Table 4, a good majority of respondents numbering 87 with a percentage of 29.0 stated the effective utilization of teaching and learning resources with ICT could help improve their understanding, while 72 (24.0%) of the respondents suggested that there is

the need for more practical lessons to enhance their understanding. Another 55 of the respondents representing 18.3% also held that the use of real or practical and familiar examples could help them reduce their learning difficulties. A small proportion of the respondents numbering 20 representing 6.7% however suggested that group projects and assignments will help them to cultivate the habit of learning independently and improve their understanding.

On the same issue, teachers' views on strategies that could be employed to lessen students' learning difficulty were elicited. A combination of questionnaire and interview were used to gather teachers' response.

A total of 12 biology teachers responded to the questionnaire and the obtained is presented in Figure 13.

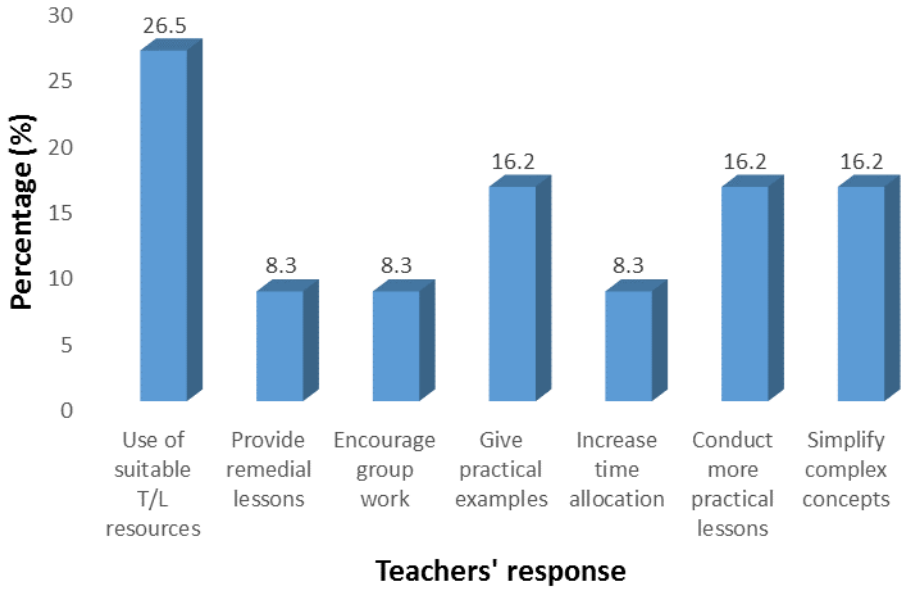

Figure 13. Teachers' strategies to lessen students' learning difficulty

According to Figure 13, 3 of the teachers with a percentage of 26.5 proposed that a lesson accompanied with suitable teaching and learning resources has the tendency to reduce students' learning challenges and therefore improve their understanding. Again, some of the teachers numbering 2 representing 16.2%, also suggested that to improve on students' performance, more practical lessons are to be conducted, practical examples which students can relate with should be cited, and complex concepts to enhance students' understanding of difficult topics should be simplified. Only 1 (8.3%) of the teachers submitted that remedial lessons should be conducted to give students a second chance at understanding the difficult topics. Another 1 (8.3%) of the teachers also suggested that encouraging group work or projects and citing of practical examples which students can easily relate with would go a long way to improve students' understanding of the topics. Again, 1 (8.3%) of the biology teachers stated that increasing time allocation for these difficult topics and seeking experts' opinion on topics they do not have in-depth knowledge about will help students to understand them better. They explained that difficult topics should be given more contact hours so that teachers get the opportunity to enhance students' understanding of the topics.

4.5 Discussion of Results

This section sought to find out the topics in biology perceived to be difficult to learn by senior high school students and to find out what practical teaching strategies could be employed to improve students' understanding in these topics. The study made use of questionnaire which was followed by interview sessions. The findings revealed that classification, Mendalian genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, cellular respiration, skeletal system, the Calvin cycle and

evolution were the most difficult topics in biology. Below is the discussion of the specific findings.

4.5.1 Topics in biology Senior High School students perceived to be difficult

The study has revealed that students have difficulty with a wide range of biology topics. Interestingly, the responses teachers gave about topics they perceived to be difficult for students to learn were the same as those obtained from the students, although not of the same order or degree of difficulty. This means that teachers are aware of their students' learning difficulties. The biology teachers indicated that, genetics, classification, the nervous system, the skeletal system, cell division and genes and chromosomes are the most difficult topics in biology as presented in Figure 11. The students, on the other hand considered classification, genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, the skeletal system, the nervous system, the Calvin cycle, cellular respiration and evolution as the most difficult topics. Results from many researches also indicate that most students perceived these topics as difficult to learn. A research conducted by Tekkaya, Özkan and Sungur (2011) indicates that hormones, genes and chromosomes, mitosis and meiosis, the nervous system, Mendalian genetics and protein synthesis are the most difficult topics in biology. Finley, Stewart and Yarroch (1982) in their study indicated that cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis were difficult for students to learn. Cell division (mitosis and meiosis), genes and chromosomes among other topics were also considered to be difficult by (Çimer, 2012).

4.5.2 Reasons why the topics were perceived to be difficult

From the results of the study, a number of factors or reasons could be attributed to why students faced some learning difficulties. According to the findings, the major reason for students' learning difficulties was the complex terms or vocabulary of the topics. Topics such as classification, genetics, the Calvin cycle are difficult because they are characterized with complex terminologies. The complex terms created a barrier in the communication process, impairing students' understanding of the concepts. According to a respondent, "*I don't like classification because the words are too big, which makes pronunciation difficult. What is even worse is that those words are easily forgotten"*. Teachers' inability to clearly explain these 'big' words to them also affected their understanding and hence made the topics difficult to learn. Similar findings have also been made by many researchers. According to Tekkaya *et. al*. (2011), Turkish students had learning difficulties because of the presence of large numbers of foreign terms in textbooks. They stated that 'it was not possible to find the exact word that gave the original meaning. In some cases, new words were invented to correspond to the English ones but these were not known by the students'. Çimer (2012) also concluded that the reason why some topics were difficult for students was that there were a lot of foreign/ Latin words in them.

The abstract and theoretical nature of the topics is another reason for students' learning difficulties. According to the respondents, concepts within the topics were not familiar and that, they could not easily relate with in the real world and so they had to picture everything to make a meaning out of it. This is consistent with findings from other researches. According to Çimer (2012), students attributed their difficulties to the nature of biology

topics and this forced them to memorize biological facts in order to learn them. This, according to him could be due to the way biology is taught. "When texts and classroom activities do not appear to be relevant to students' daily lives and do not include practical works or experiments, students may consider biology a science that just requires memorization of factual knowledge". Thus, memorization, as a biology-learning strategy was reported by biology teachers as the common learning strategy among students (Çimer, 2004). Tekkaya *et. al*. (2011) also supported the findings and stated that biology is a course that presents very many concepts, most of which depend on memorization.

Another reason for students' difficulties was the lack of practical lessons. It was clear that biology teachers failed to conduct practical lessons which could give further insight into those topics. The findings seem to suggest that the challenges students faced in these topics could not be solely blamed on lack of practical work, instead, some of the teachers ignored practical lessons because they lacked the necessary practical skills to carry out the activities. This is consistent with the thoughts of Young (1994) and Woodley (2009) who explain that teachers fail to conduct practical work because they are clumsy and awkward at performing experiments and their practical skills are so poor that they normally make wrong observations and inferences. This results also accounts for students' poor performance in biology. Again, biology teachers prefer to employ mainly traditional teaching approaches and techniques and this leads to a situation where biology lessons are run in a teacher-centered manner, where teachers act as information givers and transfer the knowledge that they have acquired which can be found in textbooks without conducting student-centered activities (Çimer, 2012).

The findings also revealed that another reason why students had difficulty with some of the biology topics is the lack of laboratory equipment and apparatus to help them conduct practical lessons. According to them, even the basic equipment and apparatus to conduct basic practical work was lacking and this resulted in the difficulty in some of the topics especially those that are abstract in nature and require practical work to make meaning. The biology teachers complained that although they wanted to conduct practical lessons for the students, the school lacked laboratory equipment and apparatus as well as the necessary materials. A similar finding was reported by Çimer (2012) who stated that the schools lacked proper biology laboratories or enough teaching and learning materials and so teachers could not conduct biological experiments and observations in the laboratories.

The study also showed that students' poor mathematical skills was one of the reasons for students' difficulties in topics involving calculations. Genetics was among the most difficult topics and this is attributed to the calculations involved. Students are asked to calculate for the phenotypic and genotypic ratios of offsprings. Genetics questions also make use of probability and percentages. Therefore, students who are weak in probability and percentages always find genetics difficult to learn. The concept of genetics may not have been entirely complex, instead students' failure to solve mathematical problems in the topic made it difficult for them. This is consistent with the work of Knippels (2002) and Osborne (2003). According to them, students who perform poorly in mathematics also do so when solving genetics problems and indeed other biological concepts that are mathematically inclined.

Biology textbooks available on the market for use is another reason for the students' learning difficulties. Some of the textbooks instead of presenting facts about concepts would also include information that are presumably unnecessary. The effect is that students will have to read long enough before they can understand the idea behind a concept. Tekkaya *et. al*. (2001) in their work identified that the difficulty in relating concepts of meiosis and genetics came from the sequence in which these topics were presented in biology textbooks. They also stressed the importance of relationships among the concepts of meiosis and genetics and the ambiguous and incorrect use of genetics concepts in textbooks. These facts not only create difficulties in learning genetics but also other concepts in biology. The presentation of figures and tables in biology textbooks is also equally important by way of explaining, contextualizing and illustration of texts, and when they are wrongly presented could lead to difficulty in making meaning.

Finally, the study has also revealed that teachers of biology for a long time have not upgraded themselves as presented in Figure 2, which indicates that 72% of teachers hold a first degree whilst only 7% hold a Master's degree. This could be one of the reasons why students experienced difficulties in some of the topics since the teachers may not have been abreast with modern teaching and learning strategies as well as modern teaching aids that could enhance students' understanding.

4.5.3 Possible practical teaching strategies to lessen students' learning difficulties

The study established that a variety of teaching and learning strategies can to be employed lessen students' learning difficulties in biology. It indicated that teachers should cultivate

the culture of preparing adequately before biology lessons as this would help them choose the appropriate teaching strategies to be employed for a particular topic. Adequate preparation is a recipe for effective delivery in the classroom, as it results in better understanding of the concept on the part of the students. Coupled with adequate preparation is the use of visual aids such as charts, animations, videos as well as other ICT tools to help students to concretize their understanding. Recent studies have indicated that students remember best the ideas or concepts that are presented in a way that relate their sensory channels, for instance, audio and visual presentations, pictures, charts, models and multimedia functions. Çimer (2012) in his work also confirmed this and suggested that teaching biology through the use of visual materials will make biology learning effective. Young (1994) and Woodley (2009) also supported this thought and suggest that the poor students' performance in biology in respect to difficult topics is as a result of some schools not having relevant teaching and learning resources required by teachers to teach the challenging topics. This means that the presence and the effective utilization of these resources would promote effective teaching and learning of biology in schools.

The study also established that, to deal effectively with the challenging topics, teachers should conduct more practical lessons. Practical work brings reality in the classroom and serves as a bridge between theory and the real world, a situation which immensely enhances students' understanding of abstract terms. As Onyegebu (2001) explained that failure to employ laboratory activities in teaching and learning made it rather difficult for students to grasp difficult biological concepts. Çimer (2012) and Tekkaya *et. al*. (2011), confirmed this when they stated that teaching through practical work is an effective way of improving students' understanding of difficult topics in biology. According to them,

students engage in learning while conducting experiments or observations because practical work allows students to learn the topics through various cognitive activities such as doing, watching, touching, talking and discussing.

Another way to lessen students' difficulties in learning these topics is for teachers to embark on remedial work or classes which would concentrate on the topics students find difficult to learn. This would give teachers the opportunity to review the concepts again giving students the opportunity of a second chance at grasping the concepts. This method would also help slow learners who are often ignored by the teacher. In addition to remedial work, teachers should also embark on revision exercises to offer students the opportunity to learn the same difficult topics to improve their understanding.

The findings also showed that students experienced learning challenges when learning difficult topics because the topics were characterized by complex terms or vocabulary. To deal with this, the teacher could cite more practical or concrete examples to illustrate the concepts. Use of concrete examples tends to enhance understanding because they are usually akin to the students' immediate environment. Çimer (2012) observed that teaching biology through connecting the topics with daily lives would help improve students' understanding. This means that when students can relate to a particular concept within their local setting, it enhances their understanding of that particular concept and learning becomes more effective. However, teachers' inability to simplify the associated complex terms could negatively affect students' ability to grasp the concept.

The study also encouraged teachers of biology to identify themselves with the Continuing Professional Development (CPD) programmes in order to develop themselves more and to ensure effective teaching of biology. Such programs as the Secondary Education Improvement Program (SEIP) and groups such as the Ghana Association of Science Teachers (GAST) provide a professional platform for teachers to share and exchange ideas on how best to teach the topics that the students perceive as difficult and. At this level, any challenge in the classroom could also be discusses and possible remedies suggested. One of the teachers confessed that, "*I always had difficulty explaining meiosis to my students, but after the SEIP workshop in Kumasi, I can now explain the concept to them better. Going for such programmes helps a lot"*. This collaboration between or among them is crucial as it sharpens teachers' pedagogical skills and makes teachers teach biology topics in a more meaningful way.

The study also identified that engaging students in group project work would go a long way to help the learning of biology. The students suggested that, if teachers would put them into groups and make them research on a particular topic and come out with their own findings, it would help them a lot. These include solving of biology questions and giving of more assignments. They believe that if they solve more biology questions related to what is being taught, they can learn biology more effectively. This also fosters cooperation and tolerance among students since in a group, members respect views of individuals and treat them as important. Again, repeating and reviewing what has been taught enables them to recall biological information much more easily.

Finally, several students indicated that teachers should make biology lessons interesting and attractive to learn more effectively. As stated earlier, biology involves a lot of abstract topics and complex vocabulary (Çimer, 2012). This makes biology lessons unattractive and boring to students and thus they develop negative attitude towards biology and its learning. Many researches indicate that there is a direct correlation between students' attitudes towards biology and their learning environment. Therefore, teachers should try and make biology lessons interesting and attractive to students because when they do the students become intrinsically motivated to learn (Çimer, 2012). This could be achieved by using visual aids, teaching through practical works, showing the links between concepts and citing examples that can be related to their everyday lives.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER STUDIES

5.0 Overview

The study has established the biology topics that Senior High School students find difficult to learn. This final chapter summarises the major findings of the study, draws conclusions, makes recommendations and suggests areas for further studies. The study was to identify the topics in biology which are perceived as difficult to learn by Senior High School students and to suggest ways of making those topics easier to understand.

5.1 Summary of Findings

According to the findings, the most difficult topics ranked in descending order of degree of difficulty are: Classification, Mendalian genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, skeletal system, cellular respiration, the Calvin cycle and evolution.

The study also identified the reasons why the topics were difficult for students to learn. Among the many reasons are: the abstract nature of the topics, the fact that most of the topics were characterised by complex terms or vocabulary. Again, some topics are too broad, there are inadequate laboratory practical work, lack of teaching and learning (T/L) resources, and teachers' failure to link the topics to everyday situations.

The study also established that some students were mathematically weak and so could not cope with topics that were mathematically inclined. As a result, they found such topics as

difficult to learn. Some teachers failed to handle difficult topics as evidenced by their inability to properly explain concepts to students.

The study also suggested a variety of teaching strategies that, could be employed to lessen students' learning difficulties. These include: adequate preparation before a biology lesson, provision and effective utilization of teaching and learning (T/L) resources, to enhance teaching and learning. Promoting active student-centered teaching strategies and employing effective communication skills, characterized by clear explanations of concepts and citing of real-life or practical examples. The study also revealed that teachers could help students understand the difficult topics better by engaging them in more laboratory or practical work, organizing remedial classes for weak and slow learners, giving challenging project or research work for students to research on and present.

Again, the study also proposed that teachers of biology could avail themselves with the Continuing Professional Development (CPD) programmes such as the Secondary Education Improvement Program (SEIP) and the Ghana Association of Science Teachers (GAST), in order to develop themselves more to ensure effective teaching of biology. This is because at the GAST and SEIP conferences, science teachers are grouped according to their areas of specialty, where they discuss identified challenges in the classroom, and come up with suggestions that could help them to deal with the challenges.

5.2 Conclusions

The study has established that the most difficult topics in the senior high school biology syllabus that students perceive as difficult to learn included: Classification, Mendalian genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, skeletal system, cellular respiration, the Calvin cycle and evolution.

These topics, according to the study were difficult because they are characterized by complex terms or vocabulary which are easily forgotten, the fact that they are abstract in nature, their broad nature, poor teachers' explanation which made it difficult for students to grasp the concepts under discussion. Some topics are also mathematical in nature and so mathematically poor students found it difficult to learn. Lack of laboratory practical work to bridge the gap between reality and fiction ad lack of suitable teaching and learning (T/L) resources to make teaching and learning effective.

In spite of the numerous students' learning challenges, the study established the use of effective teaching strategies could greatly enhance their understanding. These strategies include: regularly conducting laboratory practical work, the effective use of available teaching and learning (T/L) resources, promotion of Continuing Professional Development (CPD) groups such as the Secondary Education Improvement Programme (SEIP) and the Ghana Association of Science Teachers (GAST) and intellectual exchange of ideas among teachers. There is also the need for improvisation where there is paucity of resources, engaging students in remedial classes to help weak and slow learners to catch up.

Above all, with the numerous learning challenges students are faced with, it is the researcher's belief that given the right conditions in our schools, senior high school biology teachers have the capacity to help students deal with their learning difficulties.

5.3 Recommendations

Based on the findings and discussions of the study, the following recommendations have been made:

- Schools should be provided with biology laboratories which are well stocked with the necessary equipment, models, charts and other teaching and learning materials that are needed to make the teaching and learning of biology in senior high schools effective.
- The Ministry of Education (MOE), in collaboration with the Ghana Education Service (GES) can organize more training programs for science teachers especially teachers of biology to help them acquire modern teaching and learning strategies. The inception of the Secondary Education Improvement Programme (SEIP) which is aimed at providing training for science teachers and other science teachers' training programmes is remarkable but more of this should be encouraged.
- Biology textbooks available should be reviewed by the appropriate authorities to check how facts or concepts are presented.
- Biology should be taught dynamically not as a static subject in textbooks, but emphasize more on inquiry-based instruction that would arouse the interest of students.

5.4 Suggested areas for further study

From the findings of the research, the following are suggested for further studies:

1. An investigation into the impact of teachers' academic and professional qualification on the teaching of biology in senior high schools.
2. The extent to which available biology textbooks affect students' learning of biology.

3. Extension of the scope of the study to include other districts in other regions of Ghana.

REFERENCES

Adrine, M. (2010). Influence of biology lesson preparation and delivery on student performance in selected secondary schools in Ibanda district. Unpublished Master's dissertation. University of Makerere. Makerere.

Ajaja, O. P. (2011). Concept mapping as a study skill: Effects on students' achievement in biology. *Intellectual Journal of Educational Sciences*, *3*(1), 49-57.

Ajaja, O. P. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle? *Electronic Journal of Science Education*, *17* (1), 1-22.

Ajaja, O. P. & Eravwoke, O. U. (2010). Effects of cooperative learning strategy on junior secondary school students' achievement in integrated science. *Electronic Journal of Science Education, 14(*1), 1 – 18.

Anderson, C. W., Sheldon, T. H. & Dubay, J. (1990). The Effects of Instruction on College Nonmajors' Concepts of Respiration and Photosynthesis. *Journal of Research in Science Teaching*. *27*(8), 761 - 776.

Bahar, M., Johnstone A. H. & Hansell M. H. (1999). Revisiting learning difficulties in biology. *Journal of Biology Education*. *33*(2), 84-86.

Bennett, M. J. (1986). A developmental model of intercultural sensitivity. *International Journal of Intercultural Relations, 10*(2), 179-196.

Bennett, J. (2003). *Teaching and Learning Science: A guide to recent research and its application*. London: Continuum.

Biological Science Curriculum Study (BSCS) (1992). *Science of life and living*. Dubugue I. A: Kendall/hunt.

Brown, A. L. (1994). The Advancement of Learning. *Journal of Educational Research, 23* (8), 4 – 12.

Canas, A. J. (2003). A summary of literature pertaining to the use of concept mapping techniques and technologies for education and performance support. Retrieved: April 15, 2016. From: http://cmap.bradercomm.net:8001/rid=1186721000045_1491728413_5664/IHMC%20Literature%20Review%20on%20Concept%20Mapping.pdf.

Chiappetta E. L. & Fillman, D. A. (1998). Clarifying the place of essential topics and unifying principles in high school biology. *A Journal of School Science and Maths, 9*(10), 12-18.

Çimer, A. (2004). A study of Turkish biology: Teachers' and students' views of effective teaching in schools and teacher education. Unpublished dissertation at the University of Nottingham. Nottingham, U.K.

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Journal of Educational Research, 7*(3), 61-71.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in Education*. (6th ed.) London, U.K: Routledge Taylor and Francis group.

Dunn, R. & Boyle, R. (1999). Teaching law students through individual learning styles. Retrieved: November 28, 2015. From: http://lawteaching.org/resources/lawreviewarticles/gonzagalawreview/2002/boyle-robin.pdf.

Ezeudu, F. O. (1998). The effect of concept mapping on students' achievement, interest and retention in selected units of organic chemistry. *Review of Education*, *15*(1), 181 – 190.

Finley, F., Steward, L. & Yaroch, L. (1982). Teachers' perception of important and difficult science content. *Journal of Science Education, 66*(4), 531-538.

Frazer, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environment,* 1, 7-33.

Jegede, O. J., Alayemola, F. & Okebukola, P. A. (1992). The effect of concept mapping on students' anxiety and achievement in biology. *Journal of Research in Science Teaching*, *27*, 951-960.

Jennison, B. M. & Reiss, M. J. (1991). Does Anyone Know What Energy Is? *Journal of Biological Education, 25*(3), 173 - 174.

Johnstone A. H. & Mahmoud N. A. (1980). Isolating topics of high perceived difficulty in school biology. *Journal of Biology Education*, *14*(2), 163 - 166.

Kothari, C. R. (2004). *Research methodology: Methods and Techniques*. (2nd ed.). New Delhi: New Age International publishing limited.

Lazarowitz, R. & Penso, S. (1992). High school students' difficulties in learning biology concepts. *Journal of Biological Education, 26*(3), 215-223.

Lorsbach, A. & Tobin, K. (1997). Constructivism as a reference for science teaching. Retrieved from: https//etd.lib.melu.edu., on October 20, 2015.

Mensah, J. A., Otuka, J. & Ernest, N. W. (1995). Concept mapping: A Ghanaian secondary school students' experience. *International Journal of Science Education, 6*(4), 24 – 28.

Mullich, J. (2009). The importance of Mathematics and Science in Education. Retrieved: March 16, 2016. From: http://online.wsj.com/ad/article/mathscience-rising.

Nuhoglu, H. & Yalcin, N. (2006). The effectiveness of the learning cycle models to increase students' achievement in the physics laboratory. *Journal of Turkish Science Education, 3*(2), 28 – 30.

Obianor, E. W. (1997). The use of concept mapping to teach the concept of atom. Unpublished M.Ed. Dissertation at Nnamdi Azikiwe University, Awka, Nigeria.

Ogunkola, B. J. & Samuel, D. (2011). Science teachers' and students' perceived difficult opics in the Integrated Science Curriculum of lower secondary schools in Barbados. *World Journal of Education, 1*(2), 1-29.

Osborne, J. & Collins, S. (2001). Pupils' views of the role and value of the science curriculum. *International Journal of Science Education*, *23*(5), 441-467.

Ozcan, N. (2003). A Group of Students' and Teachers' Perceptions with Respect to Biology Education at High School Level. Unpublished MA dissertation at Middle East Technical University, Ankara, Turkey.

Ozer, O. (2004). Constructivism in Piaget and Vygotsky. Retrieved: May 25, 2016. From: www.fountainmagazine.com/Issue/detail/CONSTRUCTIVISM-in-Piaget-and-Vygotsky.

Piaget, J. (1970). Piaget's theory. In Mussen, P. (Ed), *Carmichael's manual of child psychology* (3rd ed.). New York: Wiley.

Quinn, M. & Cochran, M. (2002). *A guide to using Qualitative Research Methodology*. London: Medecins Sans Frontiers.

Seymour, J. & Longdon, B. (1991). Respiration, that's breathing: isn't it? *Journal of Biological Education*, *23*(3), 177-184.

Stevens, R. & Slavin, R. (1995). The cooperative elementary school: Effects on students' achievement, attitudes, and social relations. *American Educational Research Journal, 32*(2), 321 – 351.

Tekkaya, C., Ozkan, O. & Sungur, S. (2001). Biology concepts perceived as difficult by Turkish high school students. *Journal of Education, 21,* 145-150.

Tuna, A. & Kacar, A. (2013). The effect of 5E learning cycle model in teaching trigonometry on Students' academic achievement and the performance of their knowledge. *International Journal on New Trends in Education and their Implications, 4*(1), 73-76.

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Walbert, D. (2003). The learning cycle. Retrieved: September 9, 2015. From: www.learnnc.org/lp/pages 1663, on September 9, 2015.

West African Examination Council (2004). Chief Examiner's report for senior secondary school certificate examination (SSSCE). (p. 191).

West African Examination Council (2011). Chief Examiner's report for West African senior secondary certificate examination (WASSCE). (p. 187).

West African Examination Council (2014). Register of programmes and courses for Public and Private SHS, Technical and Vocational Institutes (pp. 2-6).

Wood, T., Cobb, P. & Yackel, E. (1995). Reflections on learning and teaching mathematics in elementary schools. Retrieved: May 6, 2016. http://www.education.com/reference/article/learning-and-teaching-mathematics/.

Woodley, E. (2009). Practical work in School science: why is it important? Retrieved: November 5, 2015. From: http://www.gettingpractical.org.uk.

Young, B. L. (1999). *Teaching Primary Science*. Hong Kong: Longman.

LIST OF APPENDICES

Appendix A: CONSENT FORM

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF SCIENCE EDUCATION

CONSENT FORM

Dear respondent,

My name is Godfred Danso. I am a student pursuing a postgraduate course, Master of Philosophy in Science Education, at the above mentioned institution. I am doing my research which is a purely academic activity whose main aim is to identify the topics students perceive as most difficult in biology, and to highlight possible strategies teachers could use to address the learning challenges. You have been chosen to participate in this study by way of voluntarily providing information. Should you accept to participate in this study, you are required to sign on this document on the slot provided below. Before appending your signature on this form, ensure that you fully understand the nature of this activity. You are therefore, encouraged to ask any question on anything not clear to you.

Note that you are free to withdraw from this study at any time if you so wish, but it is my desire that you participate in this study from the beginning up to the end.

Thank you for accepting to participate in this study.

Respondent ‘s name:…….

Phone number: …….

Signature:…….

Date: ……

Appendix B: LETTER OF INTRODUCTION

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
P. O. BOX 25, WINNEBA - TEL. NO. 0202041079

March 16, 2016.

TO WHOM IT MAY CONCERN

Dear Sir,

INTRODUCTORY LETTER

The bearer of this letter, **Godfred Danso** with Index Number **8140130005** is an M.Phik. Science Education student in the Department of Science Education in the above University.

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

He needs your assistant in filling his questionnaires.

Please give him the necessary assistant he needs.

Thank you.

VICTOR ANTWI, PH.D
Head of Department

Appendix C: Questionnaire for biology teachers

Dear Respondent,

This questionnaire is designed to collect data on students' learning difficulties in biology. The data collected will help the researcher compile a report which is a requirement for him to complete his programme of study. You are also assured that the information you supply will be treated with the greatest confidentiality it deserves, and that it is meant for only academic purposes.

Thank you for accepting to complete this questionnaire

Part A: personal details.

1. Classify your teachers by their qualifications

QUALIFICATION	Please tick (√)
Diploma	
1st Degree	
Master's Degree	
Others (Specify)……..	

2. How long have you been teaching?

a) Less than 2 years ☐

b) 3 to 5 years ☐

c) 6 to 10 years ☐

d) 10 to 15 ☐

e) More than 15 ☐

PART B: Teachers' Knowledge of students' learning difficulties in biology

(a). Tick as many as possible the topics your students find difficult to learn in the biology syllabus. You may include other topics that do not appear on the given list.

TOPIC	**Tick (√) difficult for**
Mendalian genetics	
Genes and chromosomes	
Cell division (Mitosis and Meiosis)	
Nervous system	
Protein synthesis	
Excretory system	
Homeostasis	
Photosynthesis	
Digestive system	

Transport in mammals	
Respiration (Cellular respiration)	
Skeletal system	
Evolution (Theories of evolution)	
Reproduction	
Classification	
Sensory organs (Eye, Ear, Skin)	
Endocrine system	
Genetic mutation	

(b) Explain what makes the topics you have ticked in (a) above so difficult.

Topic	**Difficult aspect of topic**	**Reasons**

(c) What challenges do you face when teaching the topics perceived as difficult by students?

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(d) Suggest interventions you would use to lessen students' difficulties in these topics.

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Appendix D: Questionnaire for students.

Dear Respondent,

This questionnaire is designed to collect data on the students' learning difficulties in biology. The data collected will help the researcher compile a report which is a requirement for him to complete his programme of study. You are also assured that the information you supply will be treated with the greatest confidentiality it deserves, and that it is meant for only academic purposes.

Thank you for accepting to complete this questionnaire.

Part A: personal details.

1. Age. [Please Tick (√)]

14 to 18 ☐

18 to 22 ☐

22 or older ☐

PART B: Topics students consider difficult in biology.

(a). Tick as many as possible the biology topics you find difficult to learn. You may include other topics that do not appear on the given list.

TOPIC	Please Tick (√)
Mendalian genetics	
Genes and chromosomes	
Cell division (Mitosis and Meiosis)	
Nervous system	
Protein synthesis	
Excretory system	
Homeostasis	
Photosynthesis	
Digestive system	
Transport in mammals	
Respiration (Cellular respiration)	
Skeletal system	
Evolution (Theories of evolution)	
Reproduction	
Classification	
Sensory organs (Eye, Ear, Skin)	
Endocrine system	
Genetic mutation	

(b) Explain what makes the topics you have ticked **(√)** in (a) above so difficult.

Topic	**Difficult aspect of topic**	**Reasons**

(c) What challenges do you face when learning these difficult topics?

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(d) Suggest ways you would want your teacher to help you learn better these difficult topics.

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Appendix E: TRIAL TEST

Answer ALL questions

[60 Minutes]

1. What biological process describes the splitting of a water molecule during the light dependent stage of photosynthesis?

   A. Photolysis of water B. Dehydrogenation of water

   C. Oxygen synthesis of water D. Electron production of water

2. The pancreas is considered both an endocrine and exocrine gland. Explain.

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3. Explain in details Lamarck's theory of evolution.

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4. During a situation of baby mix-up at Ridge Hospital, Maame Adwoa of blood group AB claims that a child of blood group O is hers. Her husband, Nana Yaw is of blood group O. But the medical doctor in charge insists that the child is not hers. Using genetic diagram(s), proof whether the action taken by the medical doctor is justified. Give reasons for your answer.

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5. (a) Specifically state what actually happens during the following phases of cell division.

(i) Prophase 1 of meiosis

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(ii) Metaphase 2 of meiosis

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(iii) Telophase of mitosis

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(b) In a tabular form, enumerate four differences between mitosis and meiosis.

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6. Briefly describe the Calvin cycle of photosynthesis.

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Appendix F: Interview schedule for biology teachers.

1. How many biology classes do you teach?
2. What is the performance of your students in biology like?
3. What topics in biology do your students find difficult to learn?
4. In your opinion, what makes these topics so difficult?
5. Do you face any challenges when teaching the topics students perceive as difficult?
6. If the answer to the above question is yes, specify these challenges.
7. How would you go round the challenges you have stated in order to help your students learn these difficult topics in biology?

Appendix G: Interview schedule for students.

1. What is your favourite science subject? Why?
2. How would you describe your performance in biology?
3. Which topics in biology do you find difficult to learn?
4. What makes these topics so difficult?
5. What specific challenges do you face when learning these difficult topics in biology?
6. How would you like your teachers to help you learn better these difficult topics in biology?