INVESTIGATION OF THE CONCEPT OF CELL BIOLOGY AS A PREREQUISITE IN UNDERSTANDING GENETICS AMONG UNIVERSITY OF BENIN UNDERGRADUATES

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY, FACULTY OF EDUCATION, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE DEGREE OF BACHELOR OF SCIENCE (EDU) IN BIOLOGY

DECEMBER, 2022

CERTIFICATION

We, the undersigned, certify that this project work was carried out by **WISDOM EGIEMAH** in the Department of Curriculum and Instructional Technology (CIT), faculty of Education, University of Benin, Benin City, in partial fulfillment for the award of B.Sc. (Ed) Degree in Biology.

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DEDICATION

This research work is dedicated to My Blossom of Love-the Lord Jesus Christ, and to my beautiful foster Mom, Elizabeth Ainerua, who gave me her love and unparalleled support.

ACKNOWLEDGEMENT

The researcher wishes to express gratitude to his project supervisor, Dr. (Mrs.) Musa, for her constructive feedback and efforts to perfect this research work.

The researcher as well expresses gratitude to all of the lecturers who taught him during his Bachelor's degree pursuit, as well as all of the non-academic staffs who work tirelessly in synergy with the school objectives; the security staffs who risk their lives night and day to keep the school free from violence and invaders, and equally ensures that every student is subject to the school orders, rules, and regulations. Kudos to the hostel caretakers for their constant coordination of the hostel's environs, the laboratory attendants who move to and fro in the laboratory rooms mobilizing lab equipment before and after use, ensuring the proper execution of our laboratory exercises, the genitors who work tirelessly to maintain our lecture halls, toilets, and the rest of the school clean, and many other non-academic personnel! The researcher also wishes to spread his sincere thanks to all the businessmen and women in the school's various cafeterias and complexes who provided us (students) easy access to buying and selling of goods and services on campus, making academic life a little easier to deal with.

The researcher would also like to thank the school's Vice Chancellor, Prof. Lillian Salami, for her motherly role in the University of Benin and her ongoing efforts to make The Great

UNIBEN a true school—an institution conducive for the teaching, and learning, and refinement of moral values.

The researcher wishes to express his gratitude to his family, firstly, to his only sibling, Faith Egiemah, for her support and constant struggle for survival. Secondly, to Mike Ainerua and his family, Elizabeth Otoaye and her family, and Kadiri Martha and her family, for their unwavering support throughout my elementary, secondary, and university education, and thirdly, to his dear friend, Christian Oviasogie and his family, for their uncommon hospitality.

Ultimately, all thanks to God Almighty for his never-ending love and mercies.

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ABSTRACT

The study was set out to investigate the concept of Cell Biology as a prerequisite in understanding Genetics among University of Benin undergraduates. A thorough statistical analysis of undergraduates' performance in Cell Biology and Genetics revealed a very interesting finding.

The ability to relate to previously established knowledge and integrate various biological concepts to form a whole is a key factor that promotes understanding, transfer of knowledge therefore paramount in the field of biology. According to Bransford and Schwartz (2000), transfer is the ability to extend what has been learned in one context to new context. This study does not argue whether students transfer and use knowledge gained from one topic to another topic. Instead, the researcher only framed his investigation on the transfer of knowledge between two related biological concept, the Cell Biology and Genetics.

The population and area of study consists of all undergraduates in university of Benin, Benin City, Nigeria, offering genetics and genetics related courses. A research hypothesis was postulated and two research questions were raised to guide the study. The study employed correlational survey research design and Regression Statistical Analysis. One hundred (100) students were randomly selected as the sample size. The instrument used in gathering the needed data for the study was the researcher's made questionnaire Data obtained was scrutinized, analyzed, scored, tabulated and was subjected to correlation coefficient statistical analysis to determine an

existing linear relationship after which regression analysis was used to determine the cause-effect of the independent variable on the dependent variable. Using these statistical methods, the findings revealed that 90% of the changes observed in the dependent variable (Genetics) were accounted for by the independent variable (Cell Biology).

CHAPTER ONE

INTRODUCTION

Background of the Study

The branch of biological science which deals with the study of how, in all living things, the characteristics and qualities of parents are given to their children by their gene is called genetics. The biological traits that are passed on to successive generations are found in the nucleus of the cell. The cell is the smallest unit of living organism which is responsible for all structural, biochemical and physiological functions of the organism. That is, cell is the basic and fundamental unit of life. There is therefore no life apart from the life of cell. Meanwhile, genetics is an integral part of mankind and all living entities.

The discovery of cell and its constituent makes the study of inheritance possible. This means that the concept of genetics is an integral part of the cell concept. Therefore this branch of biology (cell biology) stands paramount in order of studies as compared to other branches of biology.

Today study of any branch of biology is not possible in isolation as it also involves and influenced by principles, theories and concepts of other branches of biology. Lewis and Kattmann (2004) stated that genetics is considered to be one of the most difficult concepts in biology and the mechanisms are hard to understand because it is difficult to make the ideas to be tangible without the help of special instruments.

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, identification and taxonomy. Biology literally means "**the study of life**" Prof. Darshana Sharma (2020).

Currently in Nigeria, biology teaching syllabus is organized into topics, performance objectives, content, activity and notes. In spite of this planning and organization of teaching the subject, some teachers and students still find some content areas of biology difficult to teach and learn. Previous studies revised showed that there is a real problem in teachers and students understanding of different biological concepts. For instance, teachers are not sound in anatomy and genetics in the curriculum and when they do, they usually do not devote the adequate time and attention to the teaching of the concept. Many concepts in biology, especially genetics, can be perceived as difficult to learn by secondary school students and this negatively affects their performances later on in higher institutions like the university and colleges. Some teachers give the impression that genetics is an abstract and difficult area that requires a lot of brainstorming and need not to be studied (Oyewole, 2011).

The study of any biological concept is greatly influenced by what a student already know; lack of relevant prior experience or failure in noticing the relationships between different concepts could be a possible factor for not understanding any challenging concept like genetics. In this case, I therefore hypothesize that in genetics; poor knowledge of the cell concept or its misconception can limit and impede students to understand the hereditary phenomena (genetics)

and its essence for national growth and development which made the rationale base of doing this study.

Therefore, the transfer of knowledge gained in one concept to another related concept is very paramount in sciences. On the basis of this, Branford and Shwarts (1999) describe transfer as the ability to extend what has been learned in one context to new contexts.

Biology teachers often don't emphasize much on the theory of cell. This theory itself is a corner stone to understanding the unit of life. According to Omiko (2011), the knowledge of facts and theories promote attitudes of reality, objectivity, curiosity, self-examination and search of truth.

Statement of Problem

Genetics, the science of hereditary, is possibly the most difficult to comprehend biological concept in the field of biology. From personal experience and interactions with other students indicate that most undergraduates have problems with the 'basis of hereditary' and do not have a precise understanding of the underlying principles of cell biology, the very concept that pioneer the hereditary phenomenon on the basis of priority. Students fail to transfer their knowledge of the cell chromosome and the cell theory to the study of hereditary. This might be because of incomprehension of the cell Concept and its misconception; knowing only basic facts about what a cell is rather than the underlying principle and cognitive resources.

Research Questions

1. Is there any relationship between the Cell concept and Genetics?
2. Does students poor knowledge of the cell concept limits or impede their ability to understand Genetics?

Hypotheses

Poor knowledge of the Cell concept and its misconception can limit or impede the ability of students to understand the hereditary phenomenon.

Purpose of the Study

The purpose of this research work is to investigate the concept of Cell Biology on the basis of students' performance in Genetics, to determine if students' level of knowledge of the Cell concept exerts any influence or effect on their academic performance in Genetics.

Significance of the Study

The ability to relate to previously established knowledge and integrate various biological concepts to form a whole is a key factor that promotes understanding, hence, the need to survey and investigate how well students understand the Cell concept. As an integral part of hereditary, this study will possibly help in finding the cause of students' poor academic performance in Genetics.

Definition of Terms

Cell: The basic unit of a living organism, consisting of a quantity of protoplasm surrounded by a cell membrane, which is able to synthesize proteins and replicate itself.

Chromosome: The tread-like structures located inside the nucleus of animal or plant cells, often made up of protein and a DNA.

Conception: The power or faculty of apprehending and forming an idea in the mind; to recall a past experience or perception; the ability of mental abstractions.

DNA: Deoxyribonucleic acid; An organic compound whose molecule composed of two polynucleotide chains that coil around each other to form a double helix carrying genetic instructions for the development, functioning, growth and reproduction of all known organisms.

Gene: The functional and the basic unit of heredity that code for a specific trait.

Genetics: The scientific study of genes and their roles in inheritance.

Heredity: Heredity or biological inheritance is the passing on of traits from parents to their offspring via reproduction.

Nucleus: A membrane bound organelle that contains genetic material (DNA) of eukaryotic organisms.

Trait: A trait is a character of an organism that is determined by the gene.

Misconception: A wrong idea formed in the mind.

CHAPTER TWO

LITERATURE AND RERVIEW OF ELATED LITERATURE

This chapter focuses on the literature review which shall show the conceptual frame work, exposition of the cell concept from its discovery and operational definition of variables. It shall be effectively organized under the following sections, sub-headings and summary:

1. Cell Biology
- ❖ An overview of the cell concept
- ❖ Discovery of the cell
- ❖ The cell nucleus
- ❖ Composition of the nucleus
- ❖ Functions and dynamic of the nucleus
- ❖ Importance of cell
2. Genetic
- ❖ An overview of the genetic concept
- ❖ Misconception of genetics
- ❖ Brief history genetics
3. Summary of Related Literature

CELL

The animal, human or plant organisms are all but a bag of cells. All of these organisms have the same basic structural and functional unit; the cell. There are however some basic structural differences between the plant and animal cell, which provide the characteristic differences in functions. The cell is therefore the smallest, organized

unit in living things that is able to carry on all of the activities necessary for life. Some of these cells are so simple, they consist of only a single cell, such as bacteria, and are said to be unicellular. The Iroko tree and the body of a human are made of billions of cells and are said to be multicellular. The multicellular organisms are able to function through the coordinated activities of their constituent cell. (Geoffrey Obinna, 2006).

Cells are the basic building blocks of all living things. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions. Cells also contain the body's hereditary material and can make copies of them. Cells have many parts, each with a different function. Some of these parts, called organelles, are specialized structures that perform certain tasks within the cell (https://medlineplus.gov/genetics).

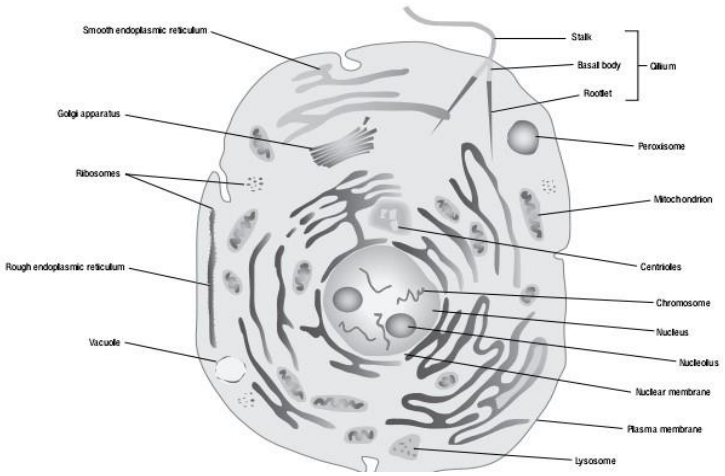

Fig 1: A Typical Animal Cell

Source: Richard Robinson, ed. In Macmillan Reference, USA, 2002.

An Overview of the Cell Concept

The cell is the smallest basic unit of all living organisms. They independently do their activities, they replicate to and divide. They are also known to be building blocks of life. The science dealing with cell study is known as cell biology or cytology. A human being is known to have more than 10 trillion of cells, mathematically it is 10^{13} cells and seen by means of a microscope, this means that you cannot see them by the naked eyes. All living organisms are composed of cells. Cells have various forms and shapes, utilities and visibility. Cells have abilities of metabolic process and this give them ability of living independently and play a huge role in living things. Scientists and various researchers strove to understand how cell itself plays interesting functions in all living things and how its absence leads to inexistence of living organisms. (Dr. Callixte Yadufashije, 2018). Cells are the basic building blocks of all living things. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions. Cells also contain the body's hereditary material and can make copies of themselves. (U.S. National Library of Medicine).

As Julie Doll (2021), put it, cells are the smallest units of life. They are a close system, can self-replicate, and are the building blocks of our bodies. And in order to understand how these tiny organisms work, the cell internal structure (which include the organelles) musts be looked upon. According to the national human genome research institution, USA, an organelle is a subcellular structure that has one or

more specific jobs to perform in the cell, much like an organ does in the body. Organelles do lots of jobs, from regulating gene transcription to producing energy or storing water. Organelles make up cells, which are basic unit of life. Cells work together to form tissues, which make up organs, organ systems, and, ultimately, multicellular organisms. Sometimes cells are compared to a factory. The factory itself is the cell, and the different departments and workers inside the factory are like the organelles inside the cell. Each one has a specific job, but they all work together to accomplish a s task. (Amanda, Jeffrey and Brenda, 2021)

Discovery of the Cell

The discovery of the microscope influenced the discovery of cells (Callixte, 2018). With the invention of the microscope at the beginning it became possible to take a first glimpse at the previously invisible world of microscopic life. A bewildering structure appeared before the astonished eyes of the first microscopists (Maxxarello, 1999). The microscopist and physicist from England Robert Hook (1635-1702) took the first description of cells in 1665. His scientific experiment conducted by making thin slices of cork and matched the boxy partitions he totally observed to the cells in a monastery. Hook observed open empty spaces but he and other scientists made their suggestions by saying that these spaces can be used to transport fluid in a living plant. They did not confirm that it is a basic unit of living organisms that they were observing. He described the microscopic units that made up the structure of a slice of cork and coined them “cells” or “pores” to refer to these units. Cella is Latin word meaning

a small room’ and Latin-speaking people applied the term cellulae to the six-sided cells of the honey-comb. By analogy, Hooke applied the term “cells” to the thickened walls of the dead cells of the cork cells. Although hooke used the word differently to later cytologists, the modern term ‘cell’ comes from his work (Maxxarello, 1999).

Researches continued developing and reach in 1824 where Frenchman Henri Milne-Edwards put out his suggestions on animal tissues, according to him animal tissues are structured like an array of globules (the basic structure of all animal tissues was an array of "globules). Henri Dutrochet (1776–1847) identified the relationship between plant and animal cells explicit, and mentioned his proposition saying that a cell was both just a structural and physiological unit, and clearly defined that everything comes from cells.

Dutrochet in his proposal, he proposed that new cells come from old cells, and François Raspail (1794–1878) echoed this idea proposed by Dutrochet and said to be his contemporary, Raspail known as the first person who supported in mentioning one of the two main tenets of cell theory: **Omnis cellula e cellula**, which means "Every cell is derived from another cell." However, despite this ringing and famous phrase, the proposed mechanism on generation of cells has not been true. He contributed on chemical composition of cells and become the father and founder of cell biochemistry.

Hugo von Mohl (1805–1872), is the one who discovered cell division despite Dumortier who preceded him. Von Mohl mentioned the word protoplasm as a material contained in the cell. Cell nucleus

is also an important part of the cell and was discussed firstly by a Czech, Franz Bauer, in 1802 and was named in 1831 by Robert Brown (1773–1858) from Scotland, and also entered other parts of nucleus description. Schleiden and Schwann, took researches on cell theory and outlined their marks and contribution in 1838 and 1839. In 1838 Matthais Schleiden (1804–1881) clarified his proposition saying that each plant types or elements is made of cells.

In 1839 a fellow German, Theodor Schwann (1810–1882), came up with propositions on animals' structure. His proposition was that all structural elements in animals are cell set products, which means that, animals are made by cells. Contribution of Schwann seems as imitating what cell theory on plant has suggested. He declared that the laws governing cells were the same or identical in both animals and plants. The Czech Jan Purkyňe (1787–1869), or Purkinje, has also contributed on cell theory and was single cytologist in his day and known as one of the most important formulators of cell theory. He used Schwann theory to explain his contribution. His proposition was that animals were made of cells and cell products and this is applied to plants. Other scientists also contributed to cell theory but these are main ones. (Callixte, 2018).

Functions and Dynamic of the Cell Nucleus

The nucleus is a membrane-bound organelle that contains genetic material (DNA) of eukaryotic organisms. As such, it serves to maintain the integrity of the cell by facilitating transcription and replication processes (Arkadeep Mitra, 2009). This is the largest of the

organelles in the mature cell except for the vacuole and is a distinguishing feature of the eukaryotic cells (Geoffrey Obinna, 2006). According to Callixte, (2018), the Cell nucleus is an important part of the cell and was discussed firstly by a Czech, Franz Bauer, in 1802 and was named in 1831 by Robert Brown. The nucleus is a highly organized structure. However, unlike cytoplasmic organelles, nuclear substructures are not bounded by membranes, but rather are held together by interactions between their component proteins and nucleic acids, and are thus probably best regarded as giant, extended multimolecular complexes. (Peter and John, 2021).

Composition of the Nucleus

The nuclear envelope is a very important feature of the eukaryotic cell. It isolates the central genetic processes of DNA replication and RNA synthesis from the cytoplasmic translation of messenger RNA into proteins. These terms had to be brought in at this point just to explain the important role played by the double nuclear envelope. (geoffrey obinna, 2006). As it contains genetic material, it coordinates cell activities like protein synthesis and cell division. (Rachel Baxter, 2021).

Structure and Organization of the Nucleus As the organelle that contains the genetic material of a cell, the nucleus can be described as the command center of a cell. As such, the nucleus consists of a number of structured elements that allow it to perform its functions. In general, the nucleus has a spherical shape. However, it may appear flattened, ellipsoidal or irregular depending on the type of cell. For

instance, the nucleus of columnar epithelium cells appears more elongated compared to those of other cells. The shape of a nucleus, however, may also change as the cell matures. The structure of a nucleus encompasses the nuclear membrane, nucleoplasm, chromosomes, and nucleolus (Arkadeep Mitra, 2009).

Anatomically the nucleus is made up of several components: nuclear lamina, nucleolus, chromosomes, nucleoplasm are some of these components.

All of these components work together in order for the nucleus to accomplish all of its functions. Namely, these functions are:

1. Control of genetic information of the cell and thus heredity characteristics of an organism.
2. Control of protein and enzyme synthesis.
3. Control of cell division and cell growth.
4. Storage of DNA, RNA and protein.
5. Production of ribosomes. (Rachel Baxter, 2021)

The Cell Theory

Hints at the idea that the cell is the basic component of living organisms emerged well before 1838-39, which was when the cell theory was officially formulated. Cells were not seen as undifferentiated structures. Some cellular components, such as the nucleus, had been visualized, and the occurrence of these structures in cells of different tissues and organisms hinted at the possibility that cells of similar organization might underlie all living matter (Mazzarello, 1999).

Importance of Cell

Cells are important parts of life and without them life can be impossible. Understanding sciences like cytology, histology, genetics, biochemistry, molecular biology, are essential sciences to know are linked to knowledge of cells (Dr. Callixte, 2018)

Adem, 2006 stressed the functions cells

1. Cell serves as the structural building block to form tissues and organ
2. Each cell is functionally independent- it can live on its own under the right conditions:
    a) It can define its boundaries and protect itself from external changes causing internal changes.
    b) It can use sugars to derive energy for different processes which keep it alive.
    c) It contains all the information required for replicating itself and interacting with other cells in order to produce a multicellular organism.
    d) It is even possible to reproduce the entire plant from almost any single cell of the plant.

GENETICS

Genetics is the biology of heredity, and geneticists are the scientists and researchers who study hereditary processes such as the inheritance of traits, distinctive characteristics, and diseases. Genetics considers the biochemical instructions that convey information from generation to generation (https://www.math.uci.edu).

An Overview of the Genetic Concept

Mendelian Inheritance refers to the process of transmitting traits from one generation to another. The inherited traits are determined by genes that are passed from parents to offspring. An offspring inherits two sets of genes—one from each parent. A trait may not be observable, but its gene can be passed to the next generation. Students have an understanding on how genes play a role in transmitting traits, but this understanding is not aligned with the biological theory. Genes are passed down from parent as a whole and identically defines traits. Although this may be true based on observations, microscopically the mechanisms of genes and variations are more complex (Benjamin and Banjoko, 2017).

Students'/Teachers' Misconception of Genetics

Misconceptions that already exist in students' minds are considered as barriers in understanding biological sciences, which may have adverse effect on subsequent learning. When students' initial understanding is not carefully considered, they may fail to grasp new concepts and information presented in the classroom, or they may learn for the purpose of test but revert to their

misconceptions outside classroom (Ozmen in Benjamin and Banjoko, 2017). New concepts can hardly be learned unless the existing misconception is corrected or students are made to bring conceptual change. However, before misconception can be corrected, they need to be identified. It is a well-known fact that students enter into biology classroom with a lot of misconceptions which are based on their beliefs and observations (Benjamin and Banjoko, 2017). The uses of the words genes, DNA, chromosomes, are interchanged in trying to explain how traits are passed from one generation to the next (Lewis and Kattmann, 2004, in Benjamin and Banjoko, 2017).

Students' misconceptions are often deeply rooted, instruction-resistant obstacles to the acquisition of scientific concepts and remain even after instruction. According to Dikmenli (2010), misconceptions are part of a larger knowledge system that involves many interrelated concepts that students use to make sense of their experiences. Students hold misconceptions that were developed before and during their early school years. One of the topics in biological field which become the research materials among educators is the difficulty of the students to understand the concept of genetics as well as the misconceptions on the connected materials (Mustami, 2016). A large number of prior studies reported that primary and secondary school students have many conceptional problems concerning cell biology and genetics (Flores et al., 2003; Lewis and Wood-Robinson, 2000; Marbach-Ad and Stavy, 2000, in Dikmenli, 2010; in Benjamin and Banjoko, 2017).

Many concepts in biology including genetics can be perceived as difficult to learn by high school students and this negatively affects their performances, (Tekkaya, Ozlem, and Sungur, 2001). A study by Mbajiorgu, Ezechi, and Idoko, (2006) revealed that science is a difficult subject to understand and grasp. Regardless of age, culture, and education background, as many students carry their own understanding of science, genetics is not an exception in this matter. Genetics is a very broad and complicated concept. Significant advances in genetics in recent decades have dramatically increased the impact of genetic information and technologies on society. Genetic issues now play a large role in health and public policy, (Kolsto 2001). In spite of this increased exposure to genetics, recent studies of the general public's genetics knowledge show a relatively low understanding of genetics concepts, (Human Genetics Commission 2001; Bates 2005).

Lewis and Kattmann (2004) also stated that genetics is considered to be one of the most difficult concepts in biology and the mechanisms are hard to understand because it is difficult to make the ideas to be tangible without the help of special instruments. The study further revealed that students come to the classroom with their own conceptions (prior knowledge) of genetics from their own experience and observations and it is important to know students' misconceptions, presuppositions, and prior knowledge in Genetics. If teachers are not aware of these misconceptions, it creates a barrier that leads to confusion and incoherence, (Lewis and Kattmann in Maigoro, Nansoh, Pam and Manji).

Lewis (2000) further emphasized the fact that the students mainly experience difficulties for explaining the relationships between the chromosome and gene concepts and the similarities and differences between mitosis and meiosis.

Not only should the teachers be aware of these misconceptions, but also the students. When students recognize these ideas, being able to change or enhance them will be easier. Students might be able to make the connections themselves. Being able to discuss their ideas can help breakdown what is wrong and right about the misconceptions. The students can actively construct and reconstruct their knowledge with the discussions, (Mbajiorgu, Ezechi, and Idoko 2006). Teachers need to accept that these presuppositions are present and they need to use it towards their advantage and the prior knowledge of the students does have a basis which needs to be clarified.

Teachers should not be discouraged in teaching Genetics, but rather use the prior knowledge of their students. It is important because students need to be able to understand the basics of Genetics in order to be literate in growing technology of science. Genes are not just this cultural idea, but a powerful scientific idea. Students will need to be science literate citizens so that they may understand their health in the present and in the future, (Venville, Gribble, & Donovan, 2004).

SUMMARY OF LITERATURE REVIEW

The goal of this chapter was to present the two concepts, cell biology and genetics, through literature excavation to sufficiently annals the both concept and reveal the breach between them.

It is evident that the genetic phenomena which is so invaluable in the field of biology and the biology of Cell came into being ‘With the invention of the microscope at the beginning, it became possible to take a first glimpse at the previously invisible world of microscopic life’. A cell biologist will argue that all living things are made of fundamental units and that cells come from pre-existing cells, Omnis cellula e cellula, which means "Every cell is derived from another cell". Albeit in the early years of this search for truth; it created skepticism and curiosity to know what those units are. Thanks to the scientists who did not relent in their search for truth. Microscope took its improvement to make their observation lucidly defined and assisted to know more on cells, diversity of cells and the dynamism of this animalculaes. The microscope has served as an important instrument to study life on the planet.

From existing literature it was well spelled out that student find it difficult to understand the concept of genetics, teachers too, sees genetics as difficult to be explained. It further stated that students mainly experience difficulties for explaining the relationships between the chromosome and gene concepts and the similarities and differences.

Without doubt and controversies, all biologists know that the nucleus houses the genetic material or the DNA that makes the transmission of inheritable biological characters from parents to their offspring possible. Thus, it is so regarded as the control center of the cell with the cell itself being the fundamental and the basic unit of life. Yadufashije, (2018) stressed that all cells have DNA in which genetic characters are located and known as the genetic material of living organisms.

The rationale base of this research work was therefore to trace the science of heredity or genetics back to its root (cell biology), to determine the relationship between the two concept under investigation and see if the cell concept can exert effect on students' performance in genetics.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter focuses on the methods and procedures used to carry out this study. It shall be effectively organized under the following sections and sub-headings:

- Design of the study
- Population of the Study
- Sample and Sampling Technique
- Research instrument
- Validation of instrument
- Method of data collection
- Scoring of the Instrument
- Method of data analysis

Design of the study

Correlational survey design was used in this study. It seeks to establish a linear relationship that may exist between two or more variables. This study indicates the direction and the magnitude of the relationship between the variables being studied but do not give room to excavate the effect of one variable on another variable. This study employs a type of statistics referred to as correlation coefficients for data analysis.

Since Correlational studies do not establish causation, but only seeks to establish relationships between two variables, regression

statistical analysis was further used to analyze and interpret the condition of the linear relationship between the two biological concepts with a view to investigate the possible cause and effects relationship. The basics of regression data analysis involves starting with an existing relationship between variables and seeking possible effect of independent variable and then collecting and analyzing of relevant data to establish the cause and effect relationship through careful interpretation of information and data collected in the field that is related to the phenomenon or concept that is under investigation.

Population of the Study

This research study was carried out in university of Benin, Edo State, Nigeria. The population and area for the study consisted of all undergraduate students offering genetics and genetics related courses in the following Departments; Biochemistry, Plant Biology & Biotechnology, Optometry, Micro Biology, Biology Education and Animal & Environmental Biology.

Sample and Sampling Technique

As a result of the inability of the researcher to effectively study the whole population under study, a representative number was chosen as the sample size of the population In order to ensure that every student fits for the sturdy has equal chance of being selected. As a result, the researcher adopted random sampling technique to select one hundred (100) students drawn from the various departments.

Research instrument

The instrument used in gathering the needed information for the study was the researcher's made questionnaire. The questionnaire consisted of two sections, section A which was titled *'characterizing students conception in Cell Biology'* and section B which was titled *'Characterizing Students Conception in Genetics'*. Section A contained ten items questionnaire about the Cell that are directly related to Genetics so as to know how well undergraduates understand the Cell Concept. While section B contained basic genetics questions that were carefully collated for the respondents so that the researcher can statistically examine their performance in Cell Biology and its effect or influence in their performance in Genetics. Options or alternatives with a point scale of Strongly Agreed, Agreed, Undecided, Disagreed, and Strongly Disagreed, were provided for each respondent to pick or tick one of the options.

More so, section C of the research instrument was not in sync with the research questions, but was deliberately included as suggested by one of the experts. According to her, the data collected from this section will be necessary and useful for recommendation for further Studies or investigation.

Validation of the Instrument

The instrument used in collecting the needed information for the study was validated by the research supervisor. The researcher also subjected the instrument to face validity by giving the instrument to two experts in the faculty of Life Science, University of Benin, to scrutinize. One of the experts, a Professor in the field of Genetics,

Department of Plant Biology and Biotechnology, scrutinized the items to ensure they are in line with the objectives of the study. The structure and language of the questionnaire were modified in the light of his corrections and suggestions. The instrument was structured in such a way as to minimize the effect of errors like inconsistency and ambiguity.

Method of data collection

The researcher's made questionnaire used in collecting the needed data from the sampled respondents for the study was structured in such a way that it provides answers to the research questions. The research instrument was designed in a précised manner to enable respondents gain understanding of the test instructions. The researcher distributed the questionnaire to the respondents; he also rendered explanations at request to the respondents in order for them to gain understanding and clarity of the test instructions. And collected back after due completion.

Scoring of the Instrument

Scoring was strictly based on the scoring manual provided by the researcher. A point scale of Strongly Agreed, Agreed, Undecided, Disagreed, and Strongly Disagreed were used to assign numerical values as follows:

- Strongly Agreed (SA) = 5
- Agreed (A) = 4
- Undecided (U) = 1
- Disagreed (D) = 3
- Strongly Disagreed (SD) = 2

Conversely, the following numerical values were assigned to statements that did not favour the application of audio-visual aids and the teaching of Biology in secondary schools:

- 2 = Strongly Agreed
- 3 = Agreed
- 1 = Undecided
- 4 = Disagreed
- 5 = Strongly Disagreed

The total score of each respondent from both sections were grouped on the basis of their performance. Stated below is the grading scale;

- 1-10 = Fail
- 11-20 = Poor
- 20-30 = Good
- 31-40 = Very good
- 41-50 = Excellent

After gathering the data through the administration of questionnaire, the collected data were coded, tabulated, and analyzed according to the research questions, hypothesis and shared characteristics of the respondents.

Method of Data Analysis

In order to statistically analyze the data collected effectively and efficiently for easy management and accuracy, correlation statistical analytical method (correlation coefficient) was used to test the hypothesis so as to identify the relationship between the two variables (Cell Biology and Genetics). To draw and reach conclusion by collecting the observed values from the questionnaire administered to respondents, testing the degree of freedom and carrying out a decision in determining the critical value of the hypothesis.

$$r = \frac{n\pounds X\ y - \pounds X\ y}{\sqrt{[n\pounds x^2 - (\pounds x)^2]\ [n\pounds y^2 - (\pounds y)^2]}}$$

Where x = independent factor

y = dependent factor

To identify the magnitude of the effect of the independent variable on the dependents variable, regression statistical analysis was adopted for the analytical study of the condition of the linear relationship that exists between the two biological concepts by carefully analyzing data collected to establish the cause and effect relationship through précised interpretation.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSSION OF FINDINGS

This chapter focuses on the research presentation and analysis of the data obtained through questionnaires. The data gathered are arranged in tables, figures and charts and are also organized in numbers, titles and interpretations, in relation to the research questions and hypothesis. The data were presented according to the order in which they were arranged in the research questions, simple percentage were used to analyze the demographic information of the respondents while spearman rank correlation was adopted to test the research hypotheses.

Under the discussion of findings, the researcher presents a comprehensive interpretation and explanation of the findings and reflected it in light of the literature reviewed.

TABLE BASED ON RESEARCH QUESTIONS AND HYPOTHESIS

Poor knowledge of the cell concept and its misconception can limit or impede the ability of students to understand the hereditary phenomenon.

To sufficiently analyze the data collected, two questions were drawn from the research hypothesis.

Research Questions One

- *Is there any relationship between the Cell and Genetics?*

Table 1.1: *Correlation Coefficient Measuring Scale (Varies From +1 To -1)*

Strength of relationship	**Positive**	**Negative**
Weak	0.1 to 0.3	-0.1 to -0.3
Medium	0.3 to 0.5	-0.3 to -0.5
Strong	0.5 to 1.0	-0.5 to -1.0

Table 1.2: *The spearman rank correlation analysis*

Cell (x)	**Genetics (y)**	**X Rank**	**Y Rank**	**Parameter**	**Values**	***Explanation***
7	6	1	1	r	0.978	*A strong positive correlation*
27	24	4	3	N Value	5	*The numbers of pairs in the data sets*
23	25	3	4	T Value	3.576	*t statistic*
29	31	5	5	*Df*	3	*Degree of freedom*
15	14	2	2	P Value	0.04	*p. value is less than the alpha value of 0.05*

From table 1.2 above, the calculated t-value, p value, n value and the degree of freedom (dm) were obtained. An alpha value of 0.05 was used as a level of significance. Using *Correlation Coefficient Measuring Scale in table 1.1 above,* the correlational coefficient of 0.978 obtained indicates that a strong positive correlation exists between the dependents and independents variables.

To sufficiently interpret this, the following null and alternate hypothesis was developed from the research question.

- ***Null hypothesis:*** *there is no linear relationship between cell biology and genetics.*
- ***Alternate hypothesis****: there is a linear relationship between cell biology and genetics.*

If the alpha value is 0.05, the null hypothesis is rejected and the alternate hypothesis is accepted if the *p* value was less than equal to 0.05. And the opposite will be true if the *p* value is greater than 0.05.

In this case, the null hypothesis was rejected and alternate hypothesis accepted because the statistical analysis indicates that *p* value (0.04) is lower than the alpha value (0.05).

Since the *p* value is less than the alpha value of 0.05, this means that there is a significant relationship between the variables and this significance relationship was positively strong (r = 0.978). Thus, performance of students in both biological concepts (Cell and Genetics) shows a strong positive correlation that is statistically significant. (See the index for quick visualization of the Regression Scatterplot Graph used for this study).

Research Questions Two

- *Does students' conception of the Cell concept affect their performance in Genetics?*

Since Correlational analysis does not establish cause-effect relationship but only seeks to establish relationships between two

variables, regression analysis was further used to analyze and interpret the linear relationship that exists between the two biological concepts with a view to answering the second research question.

REGRESSION DATA ANALYSIS

Table 2: *Summary Output*

Regression Statistics	
Multiple R	0.978
R Square	0.956
Adjusted R Square	0.941
Standard Error	2.412
Observations	5

ANOVA

	Df	***SS***	***MS***	***F***	***Significance F***
Regression	1	376.551	376.551	64.738	0.004
Residual	3	17.449	5.817		
Total	4	394			

	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	-1.487	2.880	-0.516	0.641	-10.652	7.679	-10.653	7.679
Cell	1.0637	0.132	8.046	0.004	0.643	1.484	0.643	1.484

The R^2 is the goodness of fit for the regression model which indicates that variance in the dependent variable is due to independent variable. Here, the $R^2 = 0.956$, that is, there is 95% chance that the outcome of the performance of students in genetics is due to their conception of Cell Biology.

To confirm the result, Regression Statistics, ANOVA, Intercept of Coefficient was performed for proper interpretation and discussion of findings.

In *table 3.2*, summary output, contains the regression statistics of the investigation or test; it indicates how well the calculated linear regression equation fits the data source.

The multiple R: this is the correlation coefficient value between the two variables, cell and genetics. It tells how strong the linear relationship between the two variables is. In this case r = 0.978, this indicates a very strong linear relationship between cell and genetics which is in sync with the scatterplot graph. The larger the absolute value, the stronger is the relationship. (See table). Around 90% of the changes of the independent variable (cell) accounts for the dependents variable (genetics).

R square: this is also known as the coefficient of determination. It was used to determine the effect of the independent variable (Cell) on the dependent variable (Genetics). It indicates how much variance the dependent variable can be accounted for by the independent variable. To get this value, the multiple R value was squared (0.978^2) which resulted to 0.956. And when multiplied by 100, 90% was gotten as a

percentage value. Thus, 90% of the variance in genetics can be accounted for by cell biology. Meanwhile the other 10% can be accounted for by other factors which are unknown.

The adjusted r square: adjusted R square takes into account the number of independents variables in the analysis and corrects from bias. This research work however, only involves one independent variable.

The standard error: The standard error accounts for any possible error of the mean of the group data, that is, the regression of the average distance that the observed values fall from the regression line. In this research work, the standard error is 2.880. This means that an average of the observed values were approximately 2 (two) from the regression line. The smaller the standard error the more précised the linear regression model is.

Number of observation: this is the number of groups or data points in the test. In this investigation, 100 students were grouped into 5 on the basis of their score and grading scale.

In second part of the table (ANOVA), the value under the significant F (0.004) is the subject of interest for the interpretation of the data. This is the p value for F test. If the p value is near zero then the entire statistical model is acceptable. For this research work the value is 0.004. Thus, the regression equation was statistically significant and can be used to predict the dependent variable.

In this case the p value, 0.004, associated with the overall statistics is less than the alpha value of 0.05, which indicates that the

explanatory variables “the poor performance of students in Genetics is due to their conception of the cell concept”

In the final part of the table, the first row displays the results of the intercepts coefficient which is -1.487 which coincides to the value of the regression equation or the slope of the equation (y = 1.0637x **- 1.487**). This is the point where the line of best fit or regression line crosses the Y axis when the value of x is zero. The regression equation is therefore statistically correct.

The coefficient of the intercept is this wise interpreted: Students, who do not understand the Cell concept, may not be able to conceptualize Genetics and will therefore achieve a poor performance outcome in Genetics. Conversely, if a student does well in cell biology there is likelihood that he will be able to conceptualize the Genetic phenomenon (i.e., intercept = -1.487). Since the regression equation is proven to be significantly correct, we can predict a student level of performance in Genetics by using his performance in Cell Biology as a basis for the measurement.

The second row displays the results for the slope. For a simple linear regression model, the most basic version of the equation is y = mx+b

Where y = the value of the dependent variable and the slope of the line of best fit.

X = the value of the independent variable.

b= the intercept

Using the information reported from the result, the predicted y value is

y = 1.0637 x 1.0637 - 1.487

The result obtained from the regression model was perfectly in synergy with the regression equation shown in the scatterplot graph of the correlation coefficient.

DISCUSSION OF FINDINGS

Previous research work aimed at investigating this seemingly problem in the field of biology only focus and deeply emphasize on the teaching methodology, and misconception of some basic terminology such as gene, allele, chromosome and chromatin etc. and the so called general dogma of molecular biology rather than foundational knowledge and integration of related concepts which is the rational base of this investigation, which indicates that 90% of the variance in genetics can be accounted for by cell biology. Meanwhile the other 10% can be accounted for by other factors. This finding is not in agreement with the study by Lewis and Kattmann (2004) who claimed that Genetics can only be understood through the use of special instruments. More so, many studies have characterized the difficulties experienced by students in understanding Genetics and as such focused on improving instruction and availability of qualified subject teachers to straighten up and make plain those misconceptions. But little (or possibly no) attention has been given to Cell Biology as a concept that deals with the basic unit of life from which the study of

heredity originated. This is in agreement with Callixte, 2018, who stated that sciences like Cytology, Genetics, Biochemistry, Molecular Biology, are linked to the knowledge of Cell.

If the nucleus of a cell houses the genetic material responsible for genetic information then there is need for student to first of all understand the mechanism of the totality of the cell concept, as teachers and lecturers play their roles in establishing it in the learners mind.

An Ozmen (2017) finding seems to be in synergy with the researchers findings when he postulated that when students' initial understanding is not carefully considered, they may fail to grasp new concepts and information presented in the classroom, or they may learn for the purpose of test but revert to their misconceptions outside classroom. According to Dikmenli, 2010, concepts linked to cell division and meiosis are crucial to clear understanding of numerous facet of life, including the reproduction, cell biology, genetics, and evolution, but little has changed in the way in which these subjects are taught, and comprehension has not improve.

The coefficient for each explanatory variable tells us the average expected change in the response variable, assuming the other explanatory variable remains constant, that is, if a student have a good understanding of Cell Biology, his average performance in Genetics will not be poor. For example, during the course of this study, respondent No.63 had a total score of 42 over 50 in the Cell Biology test and a total score of 41 over 50 in the Genetics test. This indicates

that the student good understanding of the Cell concept compliments his performance in Genetics. The opposite was true for respondents that performed poorly in the Cell Biology test.

The researcher therefore concluded that students' performance in Genetics is dependents on how well they understand the Cell concept since there is a significant positive linear relation between the two biological concepts and the changes observed in the dependent variable is accounted for by the independent variable. More so, the statistical analysis which indicates the p-value (0.004) is near zero or less than the alpha value (0.05), suggests that when a student is lagging behind in Cell Biology, it may create a barrier to the learning and understanding of Genetics phenomenon. Conversely, an initial understanding of the cell concept will invoke students' interest to learn and understand Genetics.

The researcher believes that the findings of this investigation through the provision of casual statistical explanation of the two concepts, understanding Cell Biology will afford students the ability to conceptualize Genetics phenomenon and activate better meaning of the science of heredity by transferring the knowledge gain in Cell Biology to Genetics, and even more advance courses or topics related to the transmission genetic information.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter of the research study consists of summary, recommendations, conclusion and references.

Summary

The purpose of this research work was to make an in-depth examination on undergraduate students offering genetics and genetics related courses by determining the linear relationship between cell biology and genetics on the basis of their performance, and to know if students' knowledge of the cell concept exerts any influence on their academic performance in genetics. For this cause, the researcher hypothesized that the poor knowledge of the cell concept and the inability for students to transfer knowledge from one biological concept to another can limit or impede their ability to understand the hereditary phenomenon.

Based on the stated objectives for the study, two research questions were drawn to guide the study. The researcher employed correlation research design in carrying out the study correlation coefficient and regression statistical analysis were used to test the causal relationship that exists between the variables. The population of the study was made up of all undergraduate students in the University of Benin that offers genetics or genetic related causes. In order to ensure that every member of the population has equal chance of being selected for the study, random sampling technique was

adopted to select one hundred (100) students. The instrument used in gathering the needed data for the study was the researcher's made questionnaire.

Conclusion

Genetics is a complicated concept that relies on thoroughly understanding the mechanism of molecular behavior of genetic information. It is true that genetics mechanisms are difficult to teach and difficult for students to grasp. But the study of any biological concept is greatly influenced by what a student already know; lack of relevant prior experience or failure in noticing the relationships between different concepts could impede any student understanding. According to most literatures, this has led to gaps in knowledge.

This study has possibly put to light one of the basic underlying reasons most students don't do well in genetics and why students perceive the entire concept of heredity as meaningless. These findings will no doubt help curriculum planners, teachers, and other educational personnel to tackle the seaming difficulties surrounding Genetics if this study is regarded with much importance as one of the core causes Genetics seems ambiguous to students over the years.

Recommendations

Based on the findings of the study, the following recommendations are put forward by the researcher:

1. Government should encourage the professional teachers especially in science related subjects through incentives

seminars on the need to integrate related concepts during class room experience.

2. Curriculum planners should encourage the integration related topics in Biology by including them in the educational syllabus of all levels of education and such topics should be organized into topics, performance objectives, content, activities and notes.

3. Ministry of Education and professional organizations like NABDA (National Biotechnology Development Agency) should organize workshops, seminars and conferences for lecturers and teachers on how to integrate various courses and topics in the field of biology especially those that are highly related conceptually.

4. Students and teachers alike should get involved in their various roles to get in sync with the knowledge of the relationship that exists between various biological phenomenon, concepts and theories in order to promote attitudes of reality, objectivity, curiosity, self-examination and search of truth when necessary.

5. There should be sensitization program; educating teachers and lecturers on the importance of transfer of knowledge from one concept to another.

Suggestion

According to the findings of this research work, it was shown that 92% of the respondents believe that the inability of teachers and lecturers to explain the Genetics concept lucidly makes the topic difficult to comprehend, and 86% perceive Genetics as too broad to learn. The researcher therefore recommends further investigation into these finding.

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APPENDIX

DEPERTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY
FACULTY OF EDUCATION
UNIVERSITY OF BENIN, EDO STATE.

QUESTIONAIRE

Respondent's No: ☐

Department: ☐

Gender: Male ☐ Female ☐

Section A

Characterizing Undergraduates' Conception in Cell Biology

Please thick the box which most closely reflect your answer

S/N	ITEMS	Strongly agree	Agree	Undecided	Disagree	Strongly Disagree
1	A sperm cell is a zygote and is haploid.					
2	Gamete cells undergo both mitosis and meiosis					
3	DNA is found inside the nucleus of a cell, but chromosomes are produced in the cytoplasm of the cell.					
4	DNA is one of the many organelles found in a eukaryotic cell.					
5	All cells come from other preexisting cells. This means that all cells are produced from other cells.					
7	A typical human cell has 22 pairs of chromosomes.					
8	Homologous chromosomes are chromosomes with similar structures.					
9	Cells starting mitosis and meiosis begin with a haploid set of chromosomes.					
10	At the end of meiosis, four cells are formed					

Section B

Characterizing Undergraduates' Conception in Genetics

Please thick the box which most closely reflect your answer

S/N	ITEMS	Strongly	Agree	Undecided	Disagree	Strongly Disagree
1	Biological traits are stored in the **RNA**					
2	Charles Darwin is regarded as the father of Genetics					
3	The symbol 'AA' is homozygote dominant.					
4	In humans, the allele for albinism is recessive to the allele for normal skin pigmentation. If two heterozygous have children, there will be 25 percent chance that a child will be albino.					
5	A DNA is made up of nitrogenous bases, a sugar molecule and a phosphate group.					
6	If a colourblind woman marries a normal vision man, their sons will be all colourblind					
7	There are 4 numbers of phenotype s in ABO blood group					
8	The alternative or contrasting form of an allele is a gene					
9	The symbol 'Aa' may represent Heterozygous dominant					
10	If two heterozygous pea plants are crossed, the first filial generation will all be homozygous dominant.					

Section C

There are several reasons why students don't do well in genetics. What are your opinions? *Please* **thick two (2) boxes** *which most closely reflect your view*

1) Interesting and comprehensible……..……...… ☐
2) Interesting but **NOT** comprehensible…….…. ……. ☐
3) The inability of secondary school teachers to explain the Genetics concept lucidly makes the topic difficult to Comprehend ……. ☐
4) There is too much to learn in the Genetics Course …….. ☐
5) I was not taught genetics in secondary school ……..……. …….. ☐

TABLES BASED ON BIO DATA AND RESPONSES OF THE RESPONDENTS

Table 1: *Gender of Respondents*

Gender	**Male**	**Female**	**Total**
Frequency	33	67	***100***
Percent	33.0	67.0	***100.0%***

Table 1 above shows the gender distribution of the respondents used for this study. 33 respondents which represent 33.0% of the population are male while the remaining 67 respondents which represent 67.0% of the population are female.

Table 2: *Cell Biology Scale Grade*

Grade	**Excellent**	**Very Good**	**Good**	**Fair**	**Poor**	**Total**
Frequency	15	29	23	27	7	***100***
Percent	15.0	29.0	23.0	27.0	7.0	***100.0%***

Table 2 above shows the grades scale used in scoring the responses of respondents. On the bases of their score and the grading

scale, out of 100% participants 15.0% were graded “Excellent”. 29.0% were graded “Very Good”, 23.0 were graded “Good”, respondents representing 27.0% were graded “Fair” while 7.0% respondents were graded “Poor”.

Table 3: *Genetics Grade Scale*

Grade	**Excellent**	**V. good**	**Good**	**fair**	**Poor**	**Total**
Frequency	14	31	25	24	6	***100***
Percent	14.0	31.0	25.0	24.0	6.0	***100.0%***

Table 3 above shows the grades scale used in scoring the responses of respondents. On the bases of their score and the grading scale, out of 100% participants 14.0% were graded “Excellent”. 31.0% were graded “Very Good”, 25.0 were graded “Good”, respondents representing 24.0% were graded “Fair” while 6.0% respondents were graded “Poor”.

TABLES BASED ON STATISTICAL ANALYSIS OF THE VARIABLES

Table 4: *Frequency Distribution of the Respondents in Cell*

Grade Range	Frequency (f) (No. of students)	Percent (No. of students in %)	Mid. Value (m)
1-10	7	7.0	5.5
11-20	27	27.0	15.5
21-3O	23	23.0	25.5
31-40	29	29.0	35.5
41-50	15	15.0	45.5
Total	***100***	***100.0***%	**127.5**

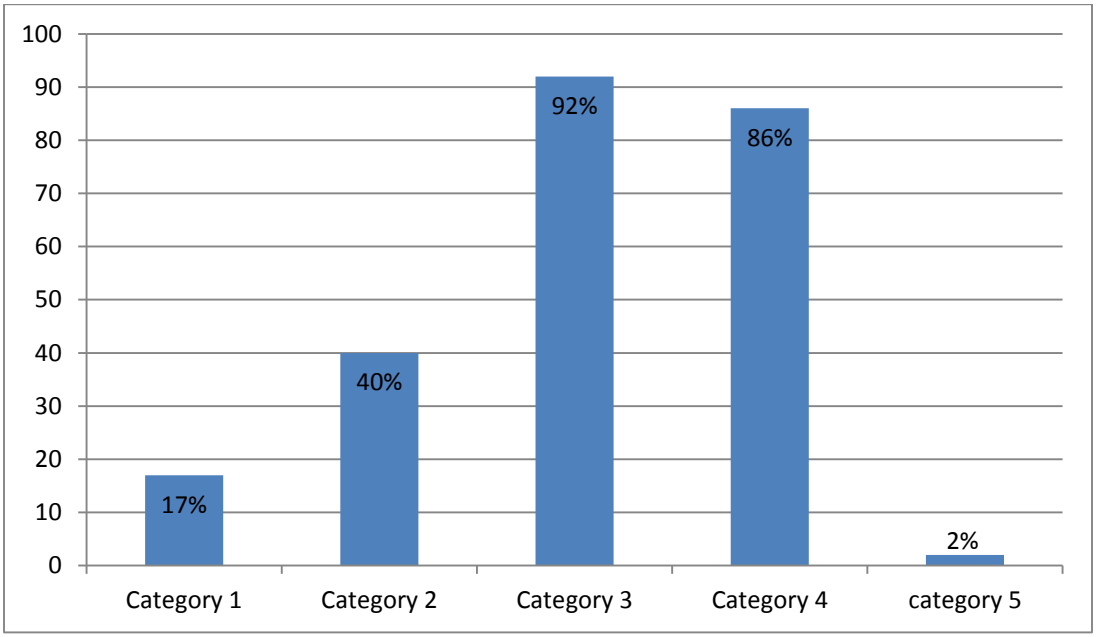
Table 4 above shows the frequency distribution of the respondents in Cell. The performance of the students was displayed on a percentage mean. 7 respondents which represent 7.0% of the population had a score that ranges from 1-10. 27 respondents which represent 27.0% of the population had a score that ranges from 11-20. 23 respondents which represent 23.0% of the population had a score that ranges from 21-30. 29 respondents which represent 29.0% of the population had a score that ranges from 31-40. And 15 respondents which represent 15.0% of the population had a score that ranges from 41-50.

Table 5: *Frequency Distribution of the Respondents in Genetics*

Grade Range	**Frequency (f) (No. of students)**	**Percent (No. of students in %)**	**Mid. Value (m)**
1-10	6	6.0	5.5
11-20	24	24.0	15.5
21-3O	25	25.0	25.5
31-40	31	31.0	35.5
41-50	14	14.0	45.5
Total	***100***	***100.0%***	**127.5**

Table 5 above shows the frequency distribution of the respondents in Genetics. The performance the students was displayed on a percentage mean. 6 respondents which represent 6.0% of the population had a score that ranges from 1-10. 24 respondents which represent 24.0% of the population had a score that ranges from 11-20. 25 respondents which represent 25.0% of the population had a score that ranges from 21-30. 31 respondents which represent 31.0% of the population had a score that ranges from 31-40. And 14 respondents which represent 14.0% of the population had a score that ranges from 41-50.

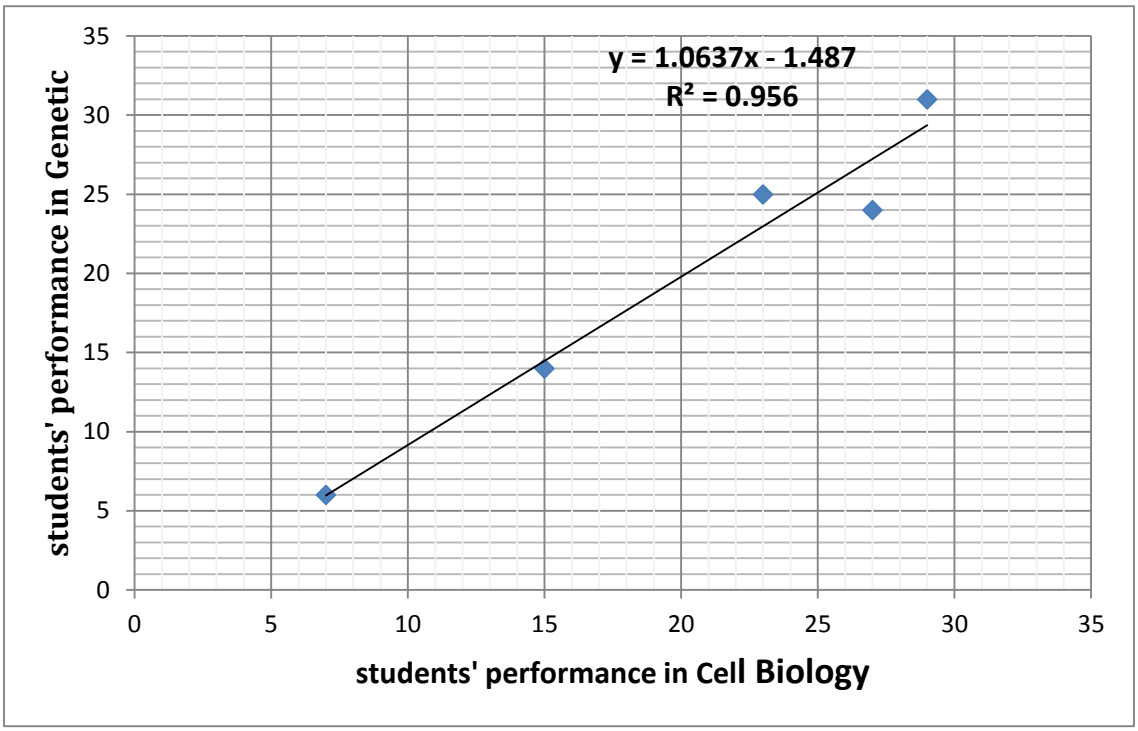
CHART BASED ON RESPONDENTS OPINIONS



The chart above shows the percentage distribution of student's opinions and feeling towards their poor performance in Genetics. The following statements were put forward (in the questionnaire) for them to tick any two which most closely reflect their views;

1. Interesting and comprehensible (Represent Category 1)
2. Interesting but NOT comprehensible (Represent Category 2)
3. The inability of teachers and lecturers to explain the Genetics concept lucidly makes the topic difficult to comprehend (Represent Category 3)
4. There is too much to learn in the Genetics Course (Represent Category 4)
5. I was not taught genetics in secondary school (Represent Category 5)

Regression Scatterplot for quick visualization of the relationship between the performance of students in Cell and Genetics



Scatterplot for the dependent and independent variable

From the graph above, it is evident that variables follow a linear increasing trend. The trend line represents the regression equation.