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Understanding the Concept of Gene among Tertiary Institution Students' in Rivers State

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ABSTRACT

The study investigated understanding the concept of gene among tertiary institution students' in Rivers State. The study adopted phenomenological design and 60 year 1 Biology Education Students volunteered which cut across three tertiary institutions in Port Harcourt (Rivers State University, University of Port Harcourt and Ignatius Ajuru University of Education), from the list of 2017/2018 academic session, there are 200 students. Students perception rating scale questionnaire (SPRSQ) constructed by the researcher was used for data collection. Face and content validation of the instrument were conducted. The reliability of the instrument was not computed in the form of reliability coefficient, hence phenomenological design was adopted for the study, and rather the instrument was pilot tested before carrying out the main study. Four research questions were formulated to address the four specific categories of the study and the research questions answered. The study as a phenomenological type of research, hypotheses were not stated, it was designed to explore and area that would later be hypothesized from the findings. Data collected were analyzed with descriptive statistics with the aid of SPSS software. The findings of the study indicated that year 1 biology educated students in tertiary institution found it difficult to describe gene, gene functions and gene related concept. The students' description and concept were that of classical and mendelian model of gene conception. The absence of hybrid conceptions and lack of modern model indicate that year 1 biology education students are unable to utilize the knowledge taught in biology. It was recommended that modern teaching methods such as problem – based learning, team - based learning, small-group discussion should be adopted in teaching genetics and there should be a re-visitation of curriculum in genetics to fill the gap where students are having lapses in the concept of gene.

Keywords: Concept of Gene, Phenomenological, Mendelian Model

INTRODUCTION

The primitive man earlier experienced biological facts and phenomenon that goes on in living things long before man began to think of science of living things, even in its most rudimentary form. He was already aware that "like begets like", that is to say, offsprings are like their parents or to an extent resemble their parents more than they resemble other adults. These can be found to be true with all living things. However, there may be slight changes in the resemblance of the progeny, but with certainty, it is known that they belong to the same species that have same ancestors. These are facts, one of the great important in genetics and understanding of gene.

The modern day genetics can rightly be said to have begun with an Australia monk Gregor Mendel (1822-84), even though, Mendel knew nothing about chromosomes and transmission of genetic materials. Towards the end of the 19th century, cytologists (cell biologists) discovered, identified and described the behaviour of chromosomes. In 20th century there was great progress in the genetics of organisms in the field of biology and raising questions and debates. The production and application of genetic technology were at its peak and there was a high level of scientific literacy and understanding of the concept (Dawson and Schibeci, 2003).

Over the years, right from the second half of the 20th century, genetics progressively became an essential field of biology also feeding controversial ethical, social and economical debates. The multiplicity and availability of products and applications of genetic technology (Genetically modified organisms). Deoxynibonucleic acid, fingerprinting, screening of genetic diseases, gene therapy, cloning, ...) are more and more daily present, requiring a high level of scientific literacy and understanding of these issues for a citizenship control (Dawson and Schibeci, 2003; Marbach-Ad, 2001).

Guzman and Bartlett (2012) stated that genetics is also one of the most difficult subjects in the biology curricula at the secondary school. The term "gene" was introduced by Wilhelm L. Johannsen in 1909. This central concept in genetics was initially defined as an entity of calculations to account for the transmission of hereditary traits. It became a material entity firstly as a part of chromosome (Morgan, 2001), and then with the development of molecular biology, as a segment of DNA. More recently, three types of genes were defined related to their functions: genes coding for proteins, genes specifying the untranslated ribonucleic acid and the regulatory genes. The more recent conceptions of gene have never totally replaced earlier conceptions: Multiple scientific conceptions of the gene are coexisting (Morange, 2004).Several authors tried to categorize them. (Griffiths, 2007) distinguished two different conceptions of the gene:

The molecular gene is "the molecular process underlying the capacity to express a particular polypeptide product", and the evolutionary gene is "a theoretical entity with a role in a particular, atomistic approach to the selection of phenotypic traits" (Griffiths and Neumann, 2009). Later, (Griffiths and Stotz, 2006) outlined three conceptions of the gene: instrumental, nominal, and postgenomic:

The instrumental gene has a critical role in the construction and interpretation of experiments in which the relationship between genotype and phenotype is explored. The nominal gene is a critical practical tool, allowing stable communication between bioscientists in a wide range of fields grounded in well-defined sequences of nucleotides, but this concept does not embody major theoretical insights into genome structure or function. The post-genomic gene embodies the continuing project of understanding how genome structure supports genome function, but with a deflationary picture of the gene as a structural unit. (Griffiths and Stotz, 2006).

Gericke and Hagberg (2007) defined five different historical models of gene function: The Mendelian model, the classical model, the biochemical-classical model, the neoclassical model and the modern model. (1) In the Mendelian model, the gene is a hypothetical construct and its main purpose is to explain genetic transmission, no connection was however made to a material unit in the cell. (2) In the classical model, the gene is a particle, an indivisible unit of genetic transmission, recombination, mutation and function. The gene determines a characteristic. Definite characteristics were the product of genes, which were located at well-defined loci on the chromosomes. (3) In the biochemical-classical model, the gene is a particle of transmission, function, mutation and recombination. The gene produces a substance that determines a characteristic. (4) In the neoclassical model, the gene is a materiel unit consisting of a DNA segment. In this model, structure and function coincide and the gene codes for the production of a polypeptide. The neoclassical view of the gene peaked at about 2000 and stated that the gene (cistron) is a contiguous stretch of DNA that is transcribed as one unit into messenger RNA, coding for a single polypeptide. (5) The modern model of gene function considers the gene as a hypothetical construct with a diverse material base consisting of DNA segments that take part in a developmental process. The gene is a producer of molecules in a developmental system. There are a number of categories of genes such as enzyme-producing genes, genes producing structural (nonsoluble) proteins, regulatory genes, and genes coding for RNA-molecules. No direct entities representing environmental aspects are present in this model.

Statement of the Problem

In Nigeria today, it has become evident that most students always fail genetics during internal and external examination according to Chief Examiner WAEC (2013).Some skip genetic when studying, the reason behind their actions could be that most of the students do not find genetics interesting or lack of understanding of some difficult concept in gene. It could also be as a result of the effect of teaching and learning methods used by most biology teachers. According to (Guzman and Bartlett, 2012; Jensen, Kummer and Banjoko, 2013), student had a difficulty tracing the flow of information from DNA to RNA to a protein product.

Some of the biology students refuse to learn on the account of negative attitude they have towards genetics topics and sometimes pretend to be learning when actually no assimilation is taking place (Brown, 2004). These students carryover this attitude to tertiary institution. In Nigeria, genetics is taught in Senior Secondary School (SS2 and SS3), most of the topics hinged on mendelian genetics, the molecular basis of heredity, a bit of principle of population genetics, and human genetics.

In tertiary institution such as colleges of Education and Universities, the teaching of genetics is treated with more details than in Secondary schools, especially in the first and second year in tertiary institutions, one module in year 1 and another module in year 2 for the preparation towards genetics courses. Classical genetics, molecular and population genetics are treated in details.

Despite this, the understanding of "gene" a concept in genetics is very low. Literature reviewed on students' knowledge in genetics indicated that students consider genetics difficult to learn more especially the gene concept and many misconceptions identified among students. Gene is an important topic for all learners in biology and this is an area where students have learning difficulties.

Understanding the concept of gene among tertiary institution students in Rivers State is the concern of the researcher in the investigation of biology education students idea about gene. Few research have until now been carried out on gene and genetics (See, Wright, Fisk, Newman, 2004) and (Guzman and barlette, 2013), But in Nigeria none has focused on gene. Therefore, this study was set out to investigate understanding of the concept of "gene" among tertiary institution students in Rivers State.

Purpose of the Study

The main purpose of the study is to investigate the understanding of the concept of gene among tertiary institutions students' in Rivers State. Specifically the study sought to:

1) Examine how biology education students describe/explain gene.
2) Examine how biology education students are able to derive categories from description of gene.
3) The extent to which biology education students describe the biological function of gene.
4) The extent to which tertiary biology students perceive the gene concept.

Research Questions

The research questions for the study are:

1) What description do biology education students ascribe to gene?
2) What are the categories of association biology education students can derived from the description of gene?
3) What extent do biology educationstudents able to describe gene function?
4) What extent do biologyeducation students perceive about gene related concept?

LITERATURE REVIEW

Theoretical Framework

This study is guided by the constructivism theory of learning based on the idea that learners construct and build their own knowledge of the world around them through experience (Piaget, 2000; Vygosky, 2008; Driver, 2008). Constructivists believe that the construction of new understanding is a combination of prior knowledge and new information. Active learners construct their knowledge with teachers acting as facilitators (Ratanaroutal and Yutakom, 2006). A distinction can be made between cognitive constructivism about how the individual learner understands things in terms of developmental stages and learning styles, and social constructivism, which emphasizes how meanings and understandings grow out of social encounters. Social constructivism views each learner as a unique individual with unique needs and background (Creswell, 2003). Social constructivists encourage the learner to arrive at his or her own version of the truth, influenced by his or her background and culture. Social constructivists take into account the background and the culture of the learner throughout the learning process. The learner's background helps to shape the knowledge and truth that the learner creates, discovers and attains in the learning process (Creswell, 2003). The learner has a responsibility for his or her learning (Petty, 2009). Teachers who are constructivists are aware of the role of prior knowledge in students' learning, recognizing that students are not blank slates or empty vessels waiting to be filled with knowledge. Instead, they believe that students bring with them a lot of prior experiences, knowledge, and beliefs that they use in constructing new understandings (Jones and Brader-Araje, 2002). This influences the pedagogical skills they employ to teach problematic topics such as genetics. These skills include group work, discussions, practical work, role play, work sheets, work cards, games and songs. These strategies engage the learners to construct knowledge by themselves. Student preconceptions have been shown to be very resistant to change. Preconceptions are based on a child's early experiences, intuitions and form a filter for later learning. In order for understanding to take place, teachers must elicit students' prior concepts and build on these concepts during instruction.

Conceptual Framework

Phenomenology Concept: Phenomenology is an approach to qualitative research that focuses on the commonality of live experience within a particular group. Through this process the researcher may construct the universal meaning of events, situation or experience and arrive at a more profound understanding of that phenomenon. Phenomenology looks at how people experience, understand and ascribe meaning to a specific situations on phenomenon (Cohen; and Manion and Morrison, 2011). Although phenomenology is used in many ways by many famous philosophers such as Kant, Hagel, Heidugger, and Hussel in the scope of research, it can be used as referring to first person moral experience, the term phenomenology is derived from the Greek 'phainein', which means 'to appear', and it was first used by Immanuel Kant in 1764. Kantian constructed by cognitive subject who is human being. In constructionist view, the subject constructs what it knows, and in phenomenological view, the subject knows what is constructed which are not appearance but has appearance in the consciousness (Rockmore, 2011).

Phenomenology is a methodological framework which has evolved into a process that seeks reality in individuals' narratives of their experiences of the phenomenon (Cilesiz, 2009), Hussert, 1970; Moustakas, 1994). Phenomenology includes different philosophies consisting of transcendental, existent and hermeneutic theories (Cilesiz, 2010). While transcend philosophy is often connected with being able to go outside of the experience, as if standing outside of ourselves to view the world from above, essential philosophy reflects a need to focus on our live experiences (Ihde, 1980; Langdrigde, 2007). On the hand, hermeneutic phenomenology emphasizes interpretation as opposed to just description.

Phenomenology comes into view in the 20th century philosophical movement based on the work of the philosophe Edmud Husserl. As a method of research based on the academic disciplines of philosophy and psychology, its method is used in describing human experiences. Phenomenology looks at how people experience, understand and ascribe meaning to a specific situation or phenomenon (Cohen; Manion, and Morrison, 2011). Phenomenological study attempts to set aside biases and preconceived assumptions about human experiences to a particular situation. The outcome of a phenomenology study is a hierarchical set of logically related categories from the narrowest and most limited to the broadest and most inclusive. It allows the researcher to delve into the perception, perspective, understandings and feelings of those people who have actually experienced or lived the phenomenon or situation of interest.

According to (Marton, 1986), an initial assumption of phenomenography is always relational and tends to adopt a second order perspective. Phenomenological research is conducted through the use of in-depth interview of small samples of participants. As the perspective of multiple participants is studied, the researcher begins to make generalisations regarding what it is like to experience a certain phenomenon from the perspective of those that have lived the experience. Phenomenology as a qualitative orientation to research takes no-dualist perspective and are used to describe the experiences of learning or teaching (Bruce and Gerber, 1995, Prosser and Trigwell, 1997).Phenomenology deals with aspect that are critically different within a group involved in the same situation, these differences makes situations qualitatively different from another. Phenomenology method has been used to identify different way of experiencing academic discipline. Example, Hazel and Prosser (1994) studied the variation in the way student understand photosynthesis.

The study has extended outcome of informing curriculum change for student-focused learning. Various element in phenomenological research are interwoven, data analysis is undertaken throughout the study, but not in concluding stage and do not require testing of hypothesis (Alamina, 2016).

Data are collected through a series of in-depth, open-ended interviews focused on allowing each participant to fully describe their experience (Bowden;Dall; Martin; Laurillar; Masters, Ramsden; Stephanou and Walsh, 1992). From what has been reviewed about phenomenological method of research, it can be deduced that phenomenology as a research method, is a direct investigation, description of phenomenon as consciously experienced by participants living those experiences. The question posed are designed to encourage the participant to think about why the experience the phenomenon in certain way and how they constitute meaning of the phenomenon. To understand phenomenological thought, one has to look at the concept involved in phenomenology. Such concept includes live experience, intentionality and noemanoesis, epohe, co-researcher.

Live Experience

This research as phenomenology deals with participants' experience with regard to the phenomenon. Van Manen (1997) as an inexperience teacher in his first day of teaching seemed to have diverse experiences compared to expert teachers who have been doing the job for years. The teacher who has been teaching for years being an expert try to put aside students' distracters that goes on in the class because he is used to it. While the inexperienced teacher feels the glance of the distractors. These can be seen as live experiences observed by two individuals on the other hand serve as the first step in phenomenological study. Hence it identifies two individual feelings on the first day of class. Phenomenological studies begin and end with people involved with live experience of the phenomenon (Creswell 2007, Moustakas, 1994, Van Manen, 1997). For the present study 'biology students understanding of gene, the researcher have to focus directly to related live experience of the participants.

Intentionality

Humans always think with consciousness that is to say, object of the experience is always created by human consciousness. Husserl (1970) opined that is a connection between perception and objects. Consciousness cannot be alone, it needs perceiving or conceiving and event (Holstein and Gubrium, 2000). Intentionality has to do with doing something deliberate, such as attending class for a purpose which does involve doing something without a purpose. Aristotle in his philosophy refers to the term 'intention' as the orientation of mind to its object. That is to say that, object existence is in the mind in an intentional way (Moustakas; 1994). Intentionality has to do with connection between the object and appearance of the object in one's consciousness. In the present study the phenomenon is the 'biology students' experience with gene for the purpose of understanding gene concept. The purpose of understanding gene concept is an intentional experience of biology students. Biology students' experience in their biology topic of 'gene' are intentional acts dependent on biology students consciousness. With this analogy, one can say, the act of experience is associated with the meaning of a phenomenon.

In the transcendental phenomenon, there are two dimensions of intentionality, they are; noema and noesis. Noema is seen as the object of experience or action, reflecting the feelings and perceptions, memories and thoughts, and judgements regarding the object. Noesis is the act of experience which includes feeling, perceiving, remembering, thinking or judging in this study.

Understanding of gene is the neoma of the experience while the biology students' experience with gene is the noesis of the experience.

Epoche

This Greek word was used by Husserl which translates to stay away or abstain from judgments about the phenomenon, as it is opined by (Langdrige, 2007). Epoche look at new point of view in order to avoid prejudgment we face with object that is familiar. These seem reason in phenomenological research making no assumption or hypothesis, as it is found in quantitative research. Epoche do not put away reality of things rather doubt scientific 'facts', advance knowledge of things outside rather than inside meaning (Moustakas, 1994), Epoche eliminates researchers bias to describe reality from object angle. Phenomenological analysis require epoche such that previous experiences of the phenomenon, should bracket the experiences of the phenomenon, should bracket the experience and knowledge about challenges related to the phenomenon in order to understand the participants' experiences entirely by staying away from prejudgment result.

Phenomenological Reduction

Phenomenological reduction duty is to describe experience of individual through 'textural language'. One carrying out phenomenological research have to consider external object associated to their perception, when describing according to (Moustakas, 1994), also take consideration of internal act of consciousness, also known as rhythm and relationship between the phenomenon and self (Langdridge, 2007). Trying to describe the general feature concerning the phenomenon, researcher have to eliminate all that are not directly within conscious experience. These elimination need to reduce the data of experiences to the manageable constituent known as unit. Phenomenological reduction require the researcher eliminating vague expressions, overlapping, repetitious and also the researcher need to clean the participants interview.

Evolving Description of Gene

Historical Development of Gene Models: Here, the comparison is drawn using Gericke and Hagberg (2007). Cateogrisation of five major models of gene function; To most scientists, the concept of a gene is not well defined. The reason is that, as discoveries and new knowledge are found, the concept of a gene begins to encompass an increasing body of knowledge. Further complicating the learning about genes and gene expression is the abstract nature of the gene concept and the multiple meanings of genes accepted in different sub-discipline in biology (Flodin, 2007; Santos, Joaqium& El-Hani, 2011). However, the concept of gene is fundamental to the development of many other concepts in the field of genetics (Gericke and Hagberg, 2007). As knowledge in genetics has progressed, scientists have needed to develop different way of explaining natural phenomena in the form of different scientific models throughout time, these models must be elaborated or completely changed to fit the current understanding of the field. This is what Gericke and Hagberg (2007) express as historical models. Nonetheless, the historical models are still in use in science education (Gericke and Hagberg, 2007, Flodin, 2009), and are often used to convey to students what they are to learn about genes and gene expression.

Gericke and Hagberg (2007) provide a detailed examination of five major historical models scientists have used to describe gene function. Each model has attempted to operationally define a gene in terms of genetic transmission, recombination, mutation and function. To determine these models, the authors described the development of gene function models by the ideas involving the structure of genes, how those genes are organised, what processes relate to genes and the entities that influence an organism. These models are defined as the Mendelian model, the classical model, the biochemical-classical model, the neoclassical model and the modern models. What follows is the description of these historical models looking briefly how those ideas developed within the scientific community and how those models can translate into student understanding about gene function.

In the Mendelian model, a gene is described as the unit of inheritance. More specifically the gene was a unit responsible for transmitting or determining a trait (Santos et al., 2011). The Mendelian model, developed in the nineteeth century, was influential in describing how phenotype traits were transmitted between organism and followed regular patterns. According to Gericke and Hagberg (2007), when Mendel's work was rediscovered in the early 1900s, scientist expanded on the idea of the gene as the unit of inheritance under this model, the focus of genes was not how they functioned within an organism, but rather on explaining of phenomenon of how genetic information was transmitted and inherited. Because of this, the genotype was regarded as the phenotype (in miniature single cell i.e a homunculus) and an abstract entity without a chemical or physiological connection to a given trait (Gericke and Hagberg, 2007). This concept of the gene also established the main unitary relationship between gene and traits (Santos et al., 2012).

The classical model began with the work of T.H Morgan in 1911 through the development of the chromosome theory of heredity. This parked a new understanding of gene in combination with the work in cytology, embryology and reproduction (Gericke and Hagberg, 2007), thus under this model, genes could be visualized using mapping techniques, and having a relationship with chromosomes as a string of beads, with each bead representing a gene that were real, indivisible particles. As Gericke and Hagberg (2007) and Santos et al. (2011) describe, this idea laid the foundation as research in the first half of the twentieth century expanded the concept of genes as more functional units in terms of transmission, recombination and mutation, of genetic information due to advancement in the chemical nature of genetics. these ideas led to genes being conceptualized as enzymes, or actors that brought about phenotypic trait (Gericke and Hagberg, 2007). As subsequent research began focusing on functional unit aspect of genes and the biochemical reactions involved, the field of genetics began to shift from transmission to gene function to biochemical nature of a gene. Thus, this is how Gericke and Hagberg (2007) separate the biochemical – classical model with work following the 1940s, which began to explain gene function in terms of the production of specific enzymes and its relationship to the determination of phenotypic traits. The previous model was revised to explain how gens functioned with later work showing that the product of genes are not always enzymes (Santos et al., 2011), shifting the idea of one gene – one enzyme o one gene – one protein. Later, with the discovery of the structure of DNA in 1953 by Watson and Crick, the material basis of inheritance was applied to genes and led to more definite terms of genotype and phenotype. With the molecular basis of genetic information identified the model of genes as particles shifted to genes as coding for information (Gericke and Hagberg, 2007).

The neoclassical model began to combine the molecular understanding of genetics to Mendel's ideas about inheritance (Santos et al., 2012). At this time the gene became to be understood as a unit of information that functions in coding for an RNA messenger, which acted as a template for specific polypeptides.

Santos et al. (2012) also discuss the concept of a gene as a molecular unit of information, and that this concept is often superimposed onto the classical-molecular concept of gene. Additionally, the researchers stated that in a more general sense, "there is not yet a sufficient and consistent theory of biological information". While Santos et al. (2012) explained that Gericke and Hagberg (2007) do not consider these concepts, they do not consider other concepts (the molecular nature of genes and genes as unit of information), and the authors do not consider these two concepts as a separate occurrence and how each relates to understanding gene function.

Genes as Units in Mendelian Genetics

Since its beginnings, Mendelian genetics was committed to the postulation of a one-to-one correspondence between a gene and some developmental unit (Griffiths and Neumann-Held, 2009). Accordingly, the gene was conceived as a unit of (1) function, (2) mutation, and (3) recombination (Mayr, 2002). In Mayr's words, this entailed a 'bean-bag' view of the genotype, according to which each gene is independent in its actions and in the effects of selection on it. The treatment of genes as 'units' faced increasing difficulties as genetic research advanced in the 20th century. Many of these problems came to light in the last three decades, but already in 1925 the first counter-evidence was provided by Sturtevant's discovery of the position effect (Mayr, 2002), showing that the function of a gene and its effect on the phenotype could be modified merely by altering the arrangement of genes in chromosomes, in the absence of mutation or any change in the quantity of genetic material. The idea that the gene could be simultaneously a unit of recombination, mutation, and function ultimately did not hold, and, in the end, the idea that prevailed was that of a gene as a 'unit of function', despite position effect. Benzer (2007) showed that units of function (in his words, 'cistrons') are typically much larger than units of recombination ('recons') and units of mutation ('mutons'). The terms 'muton' and 'recon' were deleted from the vocabulary of genetics, but 'cistron' survived to these days and is often used in the primary literature instead of 'gene.

What Is a Gene, After All?

Our current knowledge about the physical organization and dynamics of genomes brings to collapse the delicate juxtaposition of the molecular and the Mendelian gene established in the classical molecular concept. Historically, it became evident that genes are neither discrete (there are overlapping and nested genes), nor continuous (there are introns within genes); they do not necessarily have a constant location (there are transposons), and they are neither units of function (there are alternatively spliced genes and genes coding for multifunctional proteins, and gene action is strongly dependent on cellular and supra-cellular contexts), nor units of structure (there are many kinds of cisacting sequences influencing transcription, split genes, etc.). When there are so many problems with the properties used to define a concept, it is natural to ask what, after all, is the entity which is being defined. Recent advances in molecular biology, genomics and proteomics made it more and more difficult to conceive of genes as units. It is now quite clear that biological information operate at multiple hierarchical levels, in which complex networks of interactions between components are the rule, and, consequently, the understanding of the dynamics and even the structure of genes demands that they be located within complex informational networks and pathways (Ideker et al., 2001). We should move beyond the treatment of genes as units of structure and function which, secondarily, interact in complex networks. In contrast to bean-bag and deterministic views, genes themselves should be thought of in a systemic manner/context, as emergent structures produced by the network of interactions into which stretches of DNA are embedded.

Symptomatically, doubts about the status of the gene concept are found today not only in philosophical but also in empirical papers, in a manner which is suggestive – if we adopt a Kuhnian perspective – of a crisis in the paradigm that dominated molecular biology since the proposal of the double helix model. Indeed, within the community of geneticists and molecular biologists, there is a growing feeling that a change of paradigm is taking place. Two recent examples of empirical papers which express doubts about the gene concept are (Wang; Simcox; Campbell, 2000) and (Kampa, Clements, Jonas, Stuart, 2004). Kampa and colleagues, for instance, argue that their observation that 49% of the transcribed nucleotides in human chromosomes 21 and 22 amount to novel classes of RNA transcripts, while only 31.4% correspond to well-characterized genes, "strongly support the argument for a re-evaluation of the total number of human genes and an alternative term for 'gene' to encompass these growing, novel classes of RNA transcripts in the human genome" (ibid., p. 331. Emphasis added). They do not suggest that we should abandon the term 'gene' altogether, but propose that "... the 85use of the term 'gene' to identify all the transcribed units in the genome may need reconsideration", and also argue "that it may be helpful to consider using the term 'transcript(s)' in place of gene". Fogle (2000) argued that the attempt to keep and even save the idea of genes as units of structure and/or function (or, for that matter, information) led to two aspects of the now largely recognized crisis of the gene concept: the proliferation of meanings ascribed to the term 'gene' and the failure in acknowledging the diversity of gene architectures, particularly in eukaryotes. Consequently, he vigorously argued against the maintenance of the gene-as-a-unit concept – regardless of whether as a unit of inheritance, structure, function and/or information (Pardini and Guimarães, 2002; Fogle, 2000). It is this concept that cannot be reconciled with our current knowledge about the structure and functioning of genomes. This opens a door for rescuing the gene concept by redefining it in such a manner that the unit concept is dispensed with. This is a major change in our view about genes. After all, the main historical baggage of this concept lies precisely in the understanding of genes as basic units of life (Keller, 2005), which in fact predates the gene concept itself (Fogle, 2000).

The Gene Concept

The gene concept has certainly been one of the landmarks in the history of science in the 20th century. Gelbart (2008) and Keller (2000), for instance, call it 'the century of the gene. Nevertheless, at the turn of the 21st century, the future of this concept does not seem so promising, at least for some. In the last three decades, the discovery of a series of phenomena posed important challenges to the gene concept, including split genes, alternative splicing, overlapping and nested genes, mRNA edition, and so on (Falk, 2006; Pardini and Guimarães, 2002; Portin, 2009; Griffiths and Neumann-Held, 2009; Keller, 2000; Fogle, 2000). We can say that the gene concept is now between the cross and the sword. Keller (2000), for instance, suggested that maybe the time is ripe to forge new words and leave the gene concept aside. However, other philosophers of biology and also scientists have a more optimistic view about the future of this concept. Falk, while admitting that the gene is a concept 'in tension' (Falk, 2000), seeks ways to 'save' it. Hall (2001) is also optimistic, arguing that, despite published obituaries (Gray, 2002; Neumann-Held, 2009; Keller, 2000), the gene is not dead, but alive and well, even though 'orphaned', 'homeless', and seeking a haven from which to steer a course to its 'natural' home, the cell as a fundamental morphogenetic unit. Keller (2005) reexamined her ideas under the light of recent developments, assuming a more optimistic view about the future of the gene.

The Birth of the 'Gene' as an Instrumental Concept

The basic ideas in the gene concept can be traced back to Mendel's use of the German words 'Charakter', 'Element', 'Faktor', and 'Merkmale' as means of describing the determinants of particulate inheritance. Nevertheless, the term itself was created in 1909, by Johannsen. He was trying to distinguish between two ideas embedded in the term 'unit-character', then largely used: the idea of (1) a manifest character of an organism which behaves as an indivisible unit of Mendelian inheritance, and, by implication, (2) the idea of that entity in the germ-cell that produces the character (Falk, 2006). Indeed, Johannsen was the first to be entirely successful in explaining the difference between the potential for a trait and the very trait, thanks to his concepts of 'genotype' and 'phenotype' (Falk, 2006). Initially, an instrumentalist view about the status of 'gene' as a theoretical concept prevailed (Falk, 2006), i.e., just like Mendel, who treated his 'factors' simply as useful accounting or calculating units, Johannsen also conceived 'gene' as a very handy term, but with no clearly established material counterpart (Falk, 2006). Although accepting that heredity was based on physicochemical processes, he warned against the conception of the gene as a material, morphologically characterized structure. Johannsen adopted this instrumentalist attitude clearly as an outcome of the state of knowledge in his times. A gene (that 'something' which was the potential for a trait) could only be recognized by its 'representative', the trait, or, more precisely, the alternative appearances of the trait. But observed traits were only 'markers' for 'genes', which had, in fact, to be inferred. In this picture, any ascription of a clear and definite meaning to the material counterparts of genes was very difficult, maybe even impossible. With the growth of knowledge in Mendelian genetics, and through a series of developments beyond the scope of this review (such as the building of Morgan's chromosome theory of heredity and advancements in the understanding of the physicochemical basis of the genetic material, as well as of the relationship between genes and proteins (Carlson, 2006; Falk, 2006), the instrumentalist attitude was superseded by a material understanding of the gene.

A notorious member of Morgan's group, Herman J. Muller, was one of the first supporters of the idea that genes were material units, "ultra-microscopic particles" in the chromosomes, arguing against the description of the gene as "a purely idealistic concept, divorced from real things" (quoted by Falk, 2006). Muller's view contributed to the establishment of a biological setting for the subsequent investigations about the nature of the gene, which ultimately led to the proposal of the double helix model of DNA by Watson and Crick. This model was, in turn, responsible for the wide acceptance of a realist view about the gene concept.

Review of Empirical Study

Ahiakwo and Johnwest (2018) in their study investigated senior secondary students' perception about the nature of the atom. Phenomenograhic approach was adopted with 2,520 students volunteered and participated in the study. The instrument used for the data collection was perception rating scale questionnaire (PRSQ) of atoms and an Atombic Theory Test (ATT). The results show that 60% of the students described the atom in terms of shape (model). It was further observed that 10.2% of the students agreed with the statement concerning the atom as a constituent of matter, the constitution of the atom and the model of an atom. Alamina (2016) investigated students understanding of precipitation as a chemical reaction. A phenomenological design was used with one hundred and two (102) students in SS1, SS2 and SS3. Open ended interviews were used as an instrument for data collection the results indicated that students understanding of the nature of the reacting entities were mostly substance-based. Describing the different ways that students experience and understand a phenomenon is vital in development of curriculum. Unal and Zollman (1999) investigated the students' ideas about atom by asking them to describe an atom on a paper and pencil questionnaire. A phenomenological design was used with two hundred and thirty-nine (233) students. A questionnaire was used for data collection. In describing the atoms, most of the students fall into low hierarchical level of reasoning, categories. Students do not seem to retain what they have learned from previous courses or years.

Not much research has been done in relation to teaching of genetics in Africa. A few studies undertaken have concentrated on pupils understanding of genetics. One such study was done in South Africa, Sebitosi (2007) investigated the understanding of concepts about genetic inheritance in rural schools in two provinces. The participants were 15 teachers registered for a biology module presented by Sebitosi and 100 grade 11 learners who were taught by participating teachers. The schools were in rural areas. Research instruments used were written questionnaires, interviews, pre-and post-tests and focus group discussions. The findings of that study were that learners lacked understanding of the mechanisms and processes involved in genetics. The learners had problems with understanding the difference between genes and chromosomes, what is inherited and what is not, what Mendelian inheritance entails and the conflict between traditional beliefs and scientific reasoning. In South Africa, Dlamini (2009) also conducted a study to determine the level of competency in the knowledge, understanding and problem solving skills in genetics by student teachers. A class of 2008 consisting of 25 students was used for the study. The research found that the overall performance of participants in the tasks that tested higher order learning genetics was poor. The participants did better in questions that tested lower order cognitive levels such as recall. The participants showed difficulty in understanding the process of meiosis but where quite comfortable on the questions of mitosis. In addition, the study by Dlamini (2009) showed that there was a significant positive correlation between subjects' knowledge and understanding of meiosis and ability to find solutions to genetics problems. The understanding of genetics was found to be critical in the succession solution of genetics problems. Student teachers showed a lack of interpretive and analytical skills during practical work. This was evident in that some student teachers wrote models that showed more than one pair of chromosomes instead of showing a pair only. The students` lack of ability to interpret simple instructions pointed to poor language facility.

METHODOLOGY

Design of the Study

This study adopted phenomenology research design. Phenomenology is a "research method for mapping or investigating qualitatively different ways in which people experience, conceptualize, phenomena in their environment, (Marton, 1986).

Phenomenological research deals with individuals, some specific aspects of the world, and the relation by which they try to describe that aspect of the world as it appears to them. Thus, they adopt an experiential, or what phenomenographers call a "second-order", perspective (Marton, 1981).

Area of the Study

The study was carried out in three tertiary institutions in Port Harcourt metropolis, Rivers State. Port Harcourt City is one of the centres of economic activities in Nigeria and one of the major cities of Niger Delta South-South Nigeria. Port-Harcourt is the capital and largest city of Rivers State, it lies along the Bonny River. Port Harcourt is known through-out Nigeria as the "Garden City" because of it topography and scenery is located approximately on latitude 4^0 and longitude 7^0 15”. Port Harcourt has an approximate area of 272, 310, km^2 and a population Commission (NPC, 2016).

Port Harcourt is mainly dominated by the people of Ikwerre ethic nationality, Okirika minority and other people from differently parts of Nigeria. The major occupation of the people are farming, fishing and trading. The area was chosen because the selected institutions in that area offers genetics course in which gene concepts are explored.

Population of the Study

The population of the study consisted of all year One (1) Biology Education Students in three (3) tertiary institutions in Rivers State owned by the federal and state offering genetics course in 2017/2018 academic session which according to (Department of science Education, 2018) is two hundred students (200). The tertiary institutions include, university of Port Harcourt, Rivers State University, Ignatius Ajuru University of Education. The choices of the students were selected because they are currently taking genetic course and preparing to write the first semester examinations.

Sample and Sampling Techniques

The sample of the study consists of Sixty (60) year 1 Biology Education Students’ from three (3) tertiary institutions in Port Harcourt, Rivers State participated in the study. These students volunteered to take part in the study. The modal ages of the students are: 20, 22 and 23 years respectively. The participants volunteered based on their experience in genetics they had in their senior secondary school which were mainly mendelian genetics, the molecular basis of hereditary and a bit of principle of population genetics and human genetics.

Sampling in a phenomenologic type of research, the phenomena dictates the method including the type of participants (Hycner, 1999).

Method of Data Collection

The method of data collection was a STUDENT PERCEPTION RATING SCALE QUESTIONNAIRE (SPRSQ) on the understanding of gene a concept in questionnaire was constructed. On the construction of the SPRSQ, twenty (20) year One (1) Biology Education Students from a tertiary institution not involved in the study were allowed about twenty minutes to write a composition essay (see pg. 86) written specifically describing what the biology education students’ think about the nature of gene.

Based on those responses from the students, a revision and modification was made to construct more specific set of questions in four (4) categories of the study as shown in Appendix A(see pages 81 - 83).Therefore, the modified version has been used in data collection for the study. The SPRSQ questionnaire focused on first the description of gene, second was the categories that can be derived from the description of gene. Third has to do with biological function of gene and lastly, related gene concept. This provides opportunity to probe biology education students’ understanding and meaning to capture the various ideas about gene according to their responses. Each statement of the instrument consists of four (4) responses labelled: Strongly Agreed (SA), Agree (A), Disagree (D) and Strongly disagreed (SD). SA label was scored 4 points, ‘A’ scored 3 points, ‘D’ scored 2 points and SD scored 1 point.

Administration of the Instrument

Pilot Study and Protocol

This was carried out using a single school to test the instrument. One of the sampled tertiary institutions in Rivers State (Federal College of Education, Omoku) was used. This tertiary institution was used due to its nearness to the researcher. The quality of students and teachers were considered while making the choice of which schools were to be used. Before approaching the students for the administration of the pilot study composition, the researcher sought for permission from the head of the department and permission was granted. The instruments were administered to 20 students and all of them responded. Their responses were noted and presented to experts in genetics in that department who categorized participant’s responses and made corrections to validate the interview instrument. The corrections reflected in the final copy of the SPRSQ which served as instrument for data collection in the main study.

The final instrument (SPRSQ) was administered to students of biology education offering genetic in their various schools during normal school hour. In each of the questionnaire administration of the three tertiary institutions, it took at least a student twenty (20) minutes to complete the instrument.

Method of Data Analysis

The study is a phenomenological type of research and only research questions were posed. Data analysis was done using descriptive statistics of mean rating ($\bar{x}r$) for each item statement of the questionnaire with the aid

of SPSS software. The frequency distribution was obtained according to the biology education students' response labels. See Appendix D page 91– 96.To this effect, the total score for each response label was multiplied by the frequency. For example, (SA) multiply FSA, (A) multiply FA, (D) multiply FD and (SD) multiply FSA, then the total score was obtained. Thereafter the figure got are FSA +FA+FD+FSD sum up to obtain the mean rating ($\bar{x}r$)with the aid of SPSS soft ware for each item (statement of questionnaire) as shown in Appendix D (see page 91 – 96).
The decision rule on each item of the questionnaire sum of the scale weighting was divided by the number of scale thus:

$$\frac{4+3+2+1}{4} = \frac{10}{4} = \frac{5}{2} = 2.5$$

The implication of this means that mean rating $(\bar{x}r)$ less than 2.5 was rejected to explain that biology education students have no idea of gene or mixing up the concept. Also, mean rating $(\bar{x}r)$ equal to or above 2.5 was accepted to explained that biology education student have a clear understanding of gene.

Categorization of the Students' Responses

This was based on three principles as adopted in (Marton, 1986; Browden et al. 1992) namely, that:

1. Categories should be extracted from the students' responses; thus, we cannot have pre-assigned categories. In the case of this study, responses were derived from the composition of the pilot study answered by students on the description of gene, the categories that can be derived from description of gene , gene function and gene related concept.
2. Categories should not be mutually exclusive or inclusive, but distinguishable.
3. Responses must be explicit to be catagorised.

Development of Categories from Students' Responses in the Pilot Study Composition

First, four Genetic Researchers in Biology were consulted to scrutinize students' responses near in meaning to:

i. Description of gene.
ii. Categories of association that can be derived from description of a gene.
iii. Description of gene function.
iv. Gene related concept.

The three principles adopted by (Marton, 1986; Browden*et. al.*, 1992) was used as the basis for categorization of the students responses from the composition.

RESULTS AND DISCUSSIONS

Presentation and Analysis of Data

Research Question 1: *What Description do Biology Education Students Ascribe to Gene?*

Table 1: Mean Rating $(\bar{x}r)$, of how year 1 biology education students' perceived the gene according to category (CA) of the study (N = 60) .

Categories	Categories (CA) Statement	Mean Rating $(\bar{x}r)$	Decision
	C(A) Gene Description Categories		
CA_1	Gene is a unit of hereditary carrying the genetic traits	3.16	Accepted
CA_2	Gene is a unit providing the continuation of the generation.	3.06	Accepted
CA_3	Gene is a segment consisting of a combination of DNA segments	2.90	Accepted
CA_4	The gene is special unit carrying genetic knowledge on chromosomes.	2.83	Accepted
CA_5	Gene is a unit creating the genetic code of living creations	2.03	Rejected
CA_6	The gene is a nucleotide sequence	2.06	Rejected
CA_7	Gene is a unit determining inherited characteristics	1.76	Rejected
CA_8	The gene is a structure consisting DNA	2.26	Rejected
CA_9	The gene is responsible for genetic information transfer	1.81	Rejected

Source: Field Survey 2019

The result in Table 1 shows that category CA1mean rating is 3.16 which indicates acceptance of the statement as representing student's description of gene or have an idea of gene description. The analysis also shows that 32 (53.3%) students indicated strongly agreed 12(20%) students agreed to the statement. While, 10 (16.7%) indicated disagreed and six (10%) of students indicated strongly disagree.

CA_2: Mean rating value is 3.06 which is accepted. Further analysis shows that 28 (46.7%) students strongly agree and 15(25%) indicated agreed to the statement. While, 10(16.7%) disagree and seven (11.6%) indicated strongly disagreed.

CA_3: Student' responses shows that mean rating is 2.90 indicates acceptance of the statement. As such, 24 (40%) and 15 (25%) students strongly agreed and agreed respectively. While, 12 (20%) and 9(15%) students disagree and strongly disagreed the statement.

CA_4: In category (CA_4) students' responses revealed that , mean rating is 2.83 which indicates acceptance of the statement. This is because the mean rating value is above the 2.50. Twenty (33.3%) indicated strongly agreed, 15(25%) students agreed to the statement while, 20(33.3%) and 5(8.3%) students disagreed and strongly disagreed respectfully.

CA_5: Students' responses shows that mean rating is 2.03 which indicates rejection of the statement and the percentage is thus: about 12(20%) students' indicated strongly agreed and 9(15%) students indicated agreed to the statement. On the other hand, 8(13.3%) students and 31(51.7%) students indicated disagreed and strongly disagreed respectfully.

CA_6: Mean rating is 2.06 which indicate rejection of the statement by the year 1 biology education students. Further analysis shows that 12 (20%) students indicated strongly agreed and 6(10%) students agreed to the statement. While, 16(26.7%) and 26(43.3%) students disagreed and strongly disagreed respectfully to the statement.

CA_7: Students' responses revealed that mean rating is 1.76 which indicate rejection of the statement by the biology education students. As such, 8(13.3%) students indicated strongly agreed and 3(5%) indicated agreed to the statement. While, 16(26.7%) and 33(55%) students indicated disagree and strongly disagreed to the statement respectfully.

CA_8: In category (CA_8) students' responses revealed that, mean rating is 2.26 which is below 2.50 that shows rejection of the statement. The further analysis indicated that 16(26.7%) and 9(15%) students indicated strongly agreed and agreed of the statement. While, 10 (16.7%) and 25(41.6%) students disagreed and strongly disagreed respectfully.

CA_9: Students' responses shows that mean rating is 1.86 which indicates rejection of the statement by the students. The percentage of their responses is thus: about 12(20%) students indicated strongly agreed and three (5%) students indicated agreed to the statement. On the other hand, 12(16.7%) students indicated disagreed and 35(58.3%) students indicated strongly disagreed to the statement according to their response labels.

Research Question 2: *What are the Categories of Association Biology Education Students can derive from Description of Gene?*

Table 2: Mean Rating ($\bar{x}r$) of How Year 1 Biology Education Students' Perceived the Association that can be Derived from the Description of Gene According to Category (CB) of the Study (N= 60).

Categries	Categories (CB) Statement	Mean Rating ($\bar{x}r$)	Decision
	C(B) Gene Description Categories		
CB_1	DNA, Chromosome and Nucleotides base are associated with the description of gene	3.03	Accepted
CB_2	Hereditary, Mendel, homozygote, heterozygote, offspring and generation are part of the association of description of gene.	2.76	Accepted
CB_3	Protein synthesis, transcription, translation, genetic code are association that can be derived from the description of gene.	2.56	Accepted
CB_4	Category that can be associated with the description of gene are biotechnology, cloning, gene, human genome, DNA finger point.	2.50	Accepted
CB_5	Phenotype, hair colour, eye skin are part of description of gene associated concept.	2.23	Rejected
CB_6	Cell division crossover, meiosis, mitosis and reproduction are associated with the description of gene.	2.13	Rejected
CB_7	Medicine, gene therapy, health and diseases are past of description of gene associated concept.	1.98	Rejected
CB_8	Cell-tissue-organism and nucleus are associated with the description of gene.	1.86	Rejected
CB_9	Other include, evolution, genetic, biology and biodiversity are associations that can be derived from the description of gene.	1.76	Rejected

Source: Field Survey 2019

The result in Table 2 revealed that **CB_1** mean rating is 3.03 which indicate acceptance of the statement as representing students can indicate the categories of association that can be derived from description of gene. The analysis further shows that 28(46.7%) students indicated strongly agreed and 15 (25%) students agreed
to the statement. While 8(13.3%) and 9 (15%) students indicated disagreed and strongly disagreed to the statement.

CB_2: Students' responses shows that mean rating is 2.76 which indicates acceptance of the statement by the students. The percentages of their responses are as follows: 24(40%) students indicated strongly agreed and 12(20%) indicated agreed to the statement. On the other hand, 10(16.7%) and 14(23.3%) students indicated disagreed and strongly disagreed to the statement respectfully.

CB_3: In category (CB_3) students' responses revealed that mean rating is 2.56 which indicates acceptance of the statement .The further analysis shows that 20(33.3%) students indicated strongly agreed and 12(20%) agreed to the statement. While, 10(16.7%) and 18(30%) students indicated disagreed and strongly disagreed to the statement respectfully.

CB_4: Mean rating value is 2.50 which indicate acceptance of the statement by the students. Further analysis shows that 20(33.3%) students indicated strongly agreed and 9(15%) indicated agreed to the statement. While, 12(20%) and 19(31.7%) student indicated disagreed and strongly disagreed to the statement respectfully.

CB_5: Mean rating is 2.23 which indicates rejection of the statement by the year 1 biology education students. The percentage of their responses shows that 16(26.7%) indicated strongly agreed and 6(10%) indicated agreed to the statement. On the other hand, 14(23.3%) and 24(40%) students indicated disagreed and strongly disagreed to the statement respectfully.

CB6: Students' responses revealed that mean rating is 2.13 which indicated rejection of the statement. As such 16(26.7%) students indicated strongly agreed and 3(5%) indicated agreed to the statement. While 14(23.3%) and 27(45%) students indicated disagreed and strongly disagreed to the statement respectfully.

CB_7: In category (CB7) students' responses label reveled that mean rating is 1.96 which is less than 2.50 that shows rejection of the statement. The analysis also shows that 12 (20%) students indicated strongly agreed and 3(5%) indicated agreed to the statement. Besides, 14(23.3%) students indicated disagreed and 31 (51.7%) of the students indicated strongly disagreed to the statement.

CB_8: Students' responses shows that mean rating is 1.86 which indicates rejection of the statement by the students. The percentage of their responses are thus: 8(13.3)% students indicated strongly agreed and 6(10%) indicated agreed to the statement. For others, 16(26.7%) students indicated disagreed and 30(50%) students indicated strongly disagreed to the students.

CB_9: Mean rating is 1.76 which indicates rejection of the statement. The further analysis shows that 4(6.6%) students indicated strongly agreed and 9(15%) students indicated agreed to the statement. On the other hand, 16(26.7%) students indicated disagreed and 31(51.7%) students indicated strongly disagreed to the statement.

Research Question 3: *What extent biology education students are able to describe gene functions?*

Table 3: Mean Rating $(\bar{x}r)$ of How Year 1 Biology Education Students are able to Describe Gene Functions According to Category (CC) of the Study (N = 60).

Categories	Categories (CC) Statement	Mean Rating $(\bar{x}r)$	Decision
	C(C) Gene Description Categories		
CC_1	Gene play a role in regulation	3.26	Accepted
CC_2	Gene carry hereditary information	3.00	Accepted
CC_3	Gene is active particles that control character	2.30	Rejected
CC_4	Gene plays a role in transmission of hereditary information.	2.46	Rejected
CC_5	Gene determines characters.	2.16	Rejected

Source: Field Survey 2019

The result in Table 3 shows that CC_1 mean rating is 3.26 which indicates acceptance of the statement as representing students ability to describe gene functions. The further analysis shows that 32(53.3%) students indicated strongly agreed and 18(30%) indicated agreed to the statement. For others, 4(6.7%) indicated disagreed and 6(10%) of them indicated strongly disagreed to the statement.

CC_2: In category (CC_2) students responses revealed that mean rating is 3.00 which indicates acceptance of the statement by the students. Further analysis shows that 28(46.7) students indicated strongly agreed and 15(25%) indicated agreed to the statement. While, 6(10%) students indicted disagreed and 11(18.3%) of then indicated strongly disagreed to the statement.

CC_3: Students' response shows that mean rating is 2.30 indicates acceptance of the statement, as such, 16(26.7%) students indicated strongly agreed and 9(15%) indicated agreed to the statement. On the other hand, 12(.20%) and 23(38.3%) students indicated disagreed and strongly disagreed to the statement respectfully.

CC_4: Mean rating value is 2.46 which indicate rejection of the statement. The analysis also shows that 20(33.3%) students indicated strongly agreed and 9 (15%) indicated agreed to the statement. For others, 10(16.7%) and 21(35) students indicated strongly disagreed and agreed respectfully to the statement.

CC_5: Students' responses shows that, mean rating is 2.16 indicates rejection to the statement. Further analysis shows that (16(26.7%) of the students indicated strongly agreed and six (10%) indicated agreed. Besides, 10(16.6%) students indicated disagreed and 28(46.7%) indicated strongly disagreed to the statement

Research Question 4: *What Extent Biology Education Students Perceived about Gene Related Concept?*

Table 4: Mean Rating $(\bar{x}r)$ of How Year 1 Biology Education Students Perceived about Gene Related Concept According to Category (CD) of the Study (N= 60).

Categories	Categories (CD) Statement	Mean Rating ($\bar{x}r$)	Decision
	C(D) Gene Description Categories		
CD_1	Product of gene expression (protein, enzyme) are related to gene concept	3.20	Accepted
CD_2	Information-transmission (transcription and translation) are related concepts to gene.	2.93	Accepted
CD_3	Material entity of nucleotides, DNA chromatin and promoter are gene related concepts.	2.30	Rejected
CD_4	The application in cloning, restriction enzymes, gene therapy and genetic modified organism (GMO) are related to gene concept.	2.30	Rejected
CD_5	Pathological manifestations in colour blindness, down syndrome etc are not of gene related concept.	2.26	Rejected

Source: Field Survey 2019

DISCUSSION OF FINDINGS

In Table 1, it was observed that more than half of the students described "gene" as a functional unit (CA1, CA2, CA4, CA5 and CA7), others described it as a structural unit (CA8, CA6, CA3) and information transfer (CA9). Despite that, the tertiary biology education students have valid biology knowledge of gene,. The majority student's description of gene mirrored towards mendelian and classical model description of gene. In Mendelian and Classical Model, gene is a particle that provides genetic transmission and an indivisible unit of genetic transmission, recombination, mutation and function. Gene determines a character. However, in category (CA1, CA2, CA3 and CA4) the students' responses shows agreement to the statement and the mean rating is above 2.5 which indicates students' have knowledge about description of that leads to acceptance in the decision rule. While, (CA5, CA6, CA7, CA8 and CA9) majority of the students disagree and strongly disagreed to the statement and the mean rating is below 2.5 which indicates students do not have clear understanding of gene description that leads to rejection in our decision rule. The implication of this shows that, 40% (CA1 , CA2 CA3 and CA4) have perfect idea of gene description and 60% (CA5, CA6, CA7, CA8 and CA9) of gene description of biology education students do not really correspond to the scientific gene description of modern genetics. Modern genetics describe gene as a producer of molecules within a development system. Gericke and Hagberg (2007) posit that gene have several categories such as genes producing enzymes, regulator gene and genes encoding for RNA molecules. The misconception observed in the description of gene by the students is in line with the misconception observed from previous studies which include; (Marbach-Ad, 2001; Saka, Gerrah, Akdenizand Ayas, 2006; Boujamaa, Pierre and Sabah, 2010).

Table 2 result shows that association most commonly indicated by biology education students that can be derived from description of gene relates to heredity and DNA. This result was confirmed from their responses label and the attendance percentages. The students' in (CB1, CB2, CB3 and CB4) strongly agreed and agreed to the statements and the mean rating is above 2.5 that lead to acceptance in decision rule. Besides, majority of the students responses in (CB5, CB6, CB7, CB8 and CB9) indicated strongly disagreed and disagreed to the statement and the mean rating is below 2.5 that lead to rejection in the decision rule. This means 60% of the students association of gene relate more on heredity and DNA and 40% are more certain on the association that can be derived from the description of gene. This revealed that their understanding of gene association such as gene code for products other than protein, enzymes, example RNA –molecules (RNAs and RNAt) was poor. Similar observation was found in the work of (Wood-Robinson, 2000; Lewis, Leach and Wood-Robinson, 2000).

Table 3: Indicate that biology education students had difficulties in distinguishing structure of gene and their functions. This result is true and confirmed from the responses rates in CC1 and CC2 where students (40%) supported in agreement to the statement and mean rating is above 2.5 leads to acceptance in the decision rule. While, 60% responses of the students' in (CC3 CC4 and CC5)indicated disagreed to the statement and mean rating is below 2.5 leads to rejection in the decision rule. This shows that, the conception of gene function by students are not in accordance with modern scientific knowledge of gene function. This finding is consistent with the report found by (Lewis, *et. al* 2000).

In Table 4.4 Focused on concept related to gene, the students in CD1 and CD2 agreed to the statement that concept related to gene was information transmission (transcription and translation) which is 40% and the mean rating is above 2.5 leads to acceptance in the decision rule. Other indicated in CD3, CD4 and CD5 disagreed to the statement and the mean rating is below 2.5 leads to the rejection of the statement in the decision rule. This shows that none cited or referred to the fact that there may be interaction between gene and environment in the expression of different phenotypes. The majority of the students' responses only reflect to a latent genetic determinism (i.e., causality 'a gene- protein, trait). Similar result was found by (Wright, Fisk and Newman, 2014).

CONCLUSION

The study showed that, despite that biology education students received lessons from genetics in their secondary school level and first year in the tertiary institution, they found it difficult to describe gene in the modern description, associate the description with gene code for other products and description of functions of gene in accordance with scientific knowledge of gene function and also related gene concept that may interact with gene and their environment. One of the causes of these difficulties may be that teaching methodology adopted in teaching genetics at different levels is broken down into different method unsuitable to the students in learning of genetics concept which may have impaired their understanding and resulted in the difficulties they encounter in genetics topics.

RECOMMENDATION

For a better understanding of gene, biology education students should focus more on the core concept of genetics, teachers should use teaching method other than traditional method of teaching genetics, use historic discovery in genetics and relate them to the modern discovery in genetics, they should encourage students to use concept maps to generate ideas on the gene concept and compare it with historical models found in the literature.

These findings presented in this study can also be an instructional tool to help guide tertiary biology student educators. There should be a curriculum revalidation in genetics.

REFERENCES

Ahiakwo, J.M., &Johnwest, U. H (2018). Senior secondary students' perception of the nature of the atom in ObioAkpor local government area of Rivers State, Nigeria. *African Journal of Chemical Education. 8(1),*39 – 53.

Alamina, J.I. (2016). *A review of aspects of research with a focus on some common flaws observed in students projects.* Port Harcourt: Anachuna Education books.

Ashburner, M. (2000). Gene ontology: Tool for the unification of biology. *The Gene Ontology Consortium. Nat Genet 25(1):25-9.*

Avwokeni, A. J. (2004). *Practical research methodology desig, analysis and reporting.*Unicampus Tutorial Services.

Beadle, G.W & Tatum, E.L (2001) Genetic Control of biochemical reactions in neurospora proc Natic Acad Sci USA 27: 499 - 566

Bowden, J. & Marton, F. (1986).*The university of learning: Beyond quality and competence.* London: Kogan page.

Boyd C.O. (2001). *Phenomenology the method. In Munhull, P. L (ed) Nursing Research: A qualitative perspective (2nd ed., 93 – 122).* Sudbury, MA: Jones and Bartlett.

Bowden, J., Dall' Alba, G., Martin, M., Laurillard, D., Masters, G., Ramsden, P., Stephanou, A., and Walsh, E., (1992). Displacement, velocity and frames of references: Phenomenographic Studies of students' understanding and some implications for teaching and assessment. *American Journal of Physics, 60,* 262-269.

Brown, A.L. (2004). Poor reader: Teach don't label. In. Neisser (ED), *The Academic performance of University Children: New persective* (105 – 143). Hill dals, NJ: Lawrence Eribaum Associates.

Bruce, C. S, & Gerber, R (1995). "*Towards University lecturers' conceptions of student learning",* Higher Education, 29, 443 - 438

Carlson, E.A. (2006). *The Gene: A Critical History*. Saunders, pheladelphia, 301.

Cilesiz, S. (2009). Educational computer used in leisure contexts: A phenomenological study of adolescents' experience at internet cafes. *American Educational Research Journal,46(1),* 232-274.

Cilesiz, S. (2010). A phenomenological approach to experiences with technology: Current state, promise, and future directions for research. *Educational Technology Research and Development.*DOI: 10.1007/s/1423-010-9173-2.

Cohen, L., Manion, L. & Morrison, K. (2011).*Research Method in Education,* London and New York: Routledge. 7th edition

Creswell, J.W. (2003). *Advanced Mixed Method Research design.* In A. Tashakkori& C. Teddlie (Eds.), Handbook of methods in Social and behavioral research. Thousand Oaks, CA: Sage publications. Inc.

Creswell, J.W. (2007*). Qualitative inquiry and research Design Choosing among five traditions.* Thousand Oaks, CA: Sage.

Creswell, J.W. (2009). *Research Design Qualitative, quantitative and mixed methods approaches.* SAGE publications, Incorporated.

Creswell, J.W. (2012). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Dawson, V. &Schibeci, R. (2003).Western Australia School Students' attitude of biotechnology. *Journal of Biology Education, 38(1), 7-12.*

Driver , R. (1994) *Making Sense of Secondary Science: Research into Children's Ideas.* London, Routledge.

Driver, R. (2008). Students' Conceptions and Learning of Science. *International Journal of Science Education, 11,5,* 481-490.

Donovan & Bransford (2005). *How People Learn: Brain, Mind, experience, and School:* Expanded edition (31-78) (2000). Washington, DC: National Academy Press.

Dunan, R.G., & Reiser, B.J.(2007): Reasoning Across Ontological Distinct Levels: Students' understanding of molecular genetics. *Journal of Research in Science Teaching*, 447, 938-959. Doi: 10.1002/tea.20186.

Duncan, R.G., Rogat, A.D.,&Yarden, A (2009). Learning progression for deeping students understanding of modern genetics across the 5th-16th grades. *Journal of Research in Science Teaching,46(6).* 655-674. doi:10.1002/tea,201312.

Eddles-Hirsch, K. (2013). Girly girls, tomboys, athletes and nerds: A phenomenological study of social context in the specialized school environment. Scottish *Journal of arts, Social Science and Scientific Studies, 17(1), 88-101*.

El-hani, C.N. (2007). Between the cross and the sword: The crisis of the gene concept.*Genetic and Molecular Biology, 30(2),* 297-307.

Ereswell, J.W. (2003). *Advanced Mixed Method Research Design*. In A. Tashakkeri& C. Teddlie (eds.), Handbook of methods in social and behavioral research. Thousand Oaks, CA: Sage publications, Inc.

Falk, R. (2006). *The gene – A concept in tension.* In: Beurton PJ.

Falk, R. (2006). *What is gene? Stud HistPhilosSci, 17*:133-173.

Fogle, T. (2000).*The dissolution of protein coding gene*. In: Beuston, P.J., Flak, R. and Rheinberger, H. (eds), *the concept of the Gene in Development and Evolution,* Cambridge University Press, Cambridge, 3-25.

Fogle, T. (2006).*The Dissolution of Protein Coding Gene*. In: B

Fraenkel, J.R. Wallen, N.E. &Hyumrtt (2013). *How to design and evaluate research in education (8thed).* New York: McGraw Hill.

Gelbart, W. (2008).*Databases in genomic research*. Science, 282: 659-661.

Gericke, N. M., &Hagberg, M., Santos, V. C., Joaquium, L. M. & El-Hani, C. N. (2011), *Conceptual variation or incoherence?Textbook discourse on gene in six countries. Science & Education, 23(2),* 381-416.doi:10.1007/s11191-012-9499-8.

Gericke, N.M & Hargberg, M. (2006)*Definition of Historical Model of Gene function and their relation to students' understanding of genetic science & Education.* 16 (7-8), 849 – 881. Doi:10.1007/s 11191 – 006-9064s.

Gericke, N.M. & Hagberg, M. (2007).*Definition of Historical Model of Gene function and their relation to students' understanding of genetics, Sci. & Educ. 16,* 849-881.

Gerstein, M.B., Bruce, B., Rozowsky, J.S., Zheng, D., Du, J., &Korbel, J. (2007). What is a gene, post-ENCODE? History and updated definition.*Genome Research, 17,* 669-681.

Gibbs, G.R. (2007). *Analyzing qualitative data.*Tbrowbridge, Wiltshire: Sage Publications.

Giorgi, A. (2012). *The descriptive phenomenological psychology method.*

Greig, A., Taylor, J. (1999). *Doing research with children.* London: Sage.

Griffiths & Neumann, H. (2009). *The many faces of the gene.Bioscience, 46(*8), 656-662.

Griffiths, P. &Stotz, K. (2006).*Gene in the Postgenomic Era? Theoretical medium and bioethics, 27(6),* 499-521.

Guimaraes, R.C. & Moreira, C.H. (2000).O ConceitoSistemico de gene – Uma decadadepois. In: D'ottaviano IML and Gonzales MEQ (orgs) Auto-organizacao: *EstudosInterdisplinaras, v.2, Colecao CLE (Centro de LogicaeEpistomologia) v. 30 UNICAMP*, Campinas, 249-280.

Guzman, K. & Bartlett, J. (2012).*Using Simple Manipulative to improve Student Comprehension of a Complex Biology Process.Biochem.Mol Bio Educ,* 40(5), 320-327. doi: 10.1002/bmb.20638.

Hazel, E., Prosser, M. (1994), "First-Year University Students' Understanding of photosynthesis, their study strategies and learning context*," American Biology Teacher, 56, 274 – 279.*

Holstein, J.A., & Gubrium, J.B. (2000).*Interpretive practice and social Action.In N.*

Huberman, A.M. (1994). *Qualitative data analysis*: *An expanded sourcebook*. Thousand Oaks, CA: Sage.

Husserl, E. (1970*). Logical Investigation (vols. 1-2) (J.N. Findlay, Trans.)* New York: Humanities Press.

Ideker, T., Galitski, T. & Hood, L. (2001).*A new approach to decoding life.Systems biology. Annu Rev Genomics Hum. Genet, 2:*343-372.

Ihde, D. (1986). *Experimental phenomenology*: An introduction Albany: State University of New York Press.

Jensen, J.L. Kummer, T.A. &Banjoko, A. (2013).Assessing the effects of prior conception on learning gene expression.*Journal of College Science Teaching, 42(4),* 82-91.

Johannsen, W. (1909) *Elopemente der Exakten Erblihkeitslehve.* Gustar Fisher, Jena, 723.

Jones, M.G. &Brader-Araje, L. (2002).*Impact of constructivism on Education*: Language Discourse, and meaning. American community journal.3(8).

Kampa, B.M; Clements, J., Jonas, P.; Staurt, GP. (2004) *Kinetics of Mg^{2+} unlock of NMDA receptors*; implications for spike timing dependant synaptic placticity. Physiol
(55:337-45).

Keller, E.F. (2005). *The century beyond the gene*. J Biosci, 30:3=10.

Keller, L.E. (2000). *The century of the gene.* Harvard University Press, Cambridge, 192.

Keller, L.E. (2006). *Who wrote the book of life*? *A history of the genetic code.* Stanford University Press, Stanford, 441.

Keller, R.F. (2000). *The century of gene*. Harvard University Press, Cambridge, 192.

Kruger, D. (1998). *An introduction to phenomenology psychology* (2^{nd}ed.). Capetown, South Africa: Juta.

Langdridge, D. (2007). *Phenomenological psychology:* Theory, research and methods. Harlow, Pearson Education.

Lewis, J., & Kattman, U. (2004). Traits, genes, particles and information: Revisiting students' understanding of genetics. *International Journal of Science Education,* 26(2), 195-206. Doi: 10.1080/0950069032000072782.

Lewis, J., Leach, J., & Wood-Robinson, C. 92000).All in the genes? – Young people's understanding of the nature of genes. *Journal of Biological Education,34(2),* 74-79.

Magre, E. (2002). *The growth of biological thought: Diversity evolution and inheritance.* Harvard University Press, Cambridge , 974.

Marbach – Ad, G. (2001). Attempting to break the code in student comprehension of genetics concepts, *Journal of Biological Education,35(4),* 183-189.

Marbach – Ad, G., &Stavy, R. (2000). Students' cellular and molecular explanation of genetics phenomena. *Journal of Biological Education,34(4),* 200-205.

Marshall, C. & Rossman, G.B. (2006).*Designing Qualitative Research.* Thousand Oaks, CA: Sage publications.

Marton, F. (1981).Phenomenography: Describing conception of the world around us. *Instructional science (10),* 177-200.

Marton, F., (1986).Phenomenography – A research approach to investigating different understanding of reality. *Journal of thought, 21, 29-39.*

Marriam, S.B. (1992). *Qualitative Research and Case Study Application in education revised and expanded from case study research in Education.* CA: Jossey-Bass publishers.

Marriam, S.B. (1995). *What can you tell from an N of I? issues of validity and reliability of qualitative research.* PAACE: Journal of Lifelong Learning, 4,51 – 60.

Mayre, E. (2002). *The growth of biological thought: Diversity:* Diversity, Evolution and inheritance Harvard University Press. Cambridge. 97.

Morange, M. (2004).*Redefinition of the concept of Gene.Medicine science, 20(1),* 835-836.

Morgan, D.L (1997). *Focus group as qualitative research.* Thousand Oaks, CA: Sage.

Morgan, T.H. (2001). The origin of five mutations in eye colour in drosphila and their mode of inheritance.*Science, 33, 534.*

Mousakas, C. (1994). *Phenomenological Research Methods. Thousand Oaks,* CA: Sage.

Okoye, N. S. &Okechukwu, R.N. (2006).Effect of concept mapping and problem solving teaching strategies in genetics among Nigeria secondary school students.*African journal of educational studies in mathematics and science.*vol.4, 95-98.

Ozmen, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bounding. *Journal of Science Education and Technology,13(2),* 147-159.

PardiniMimc and Guimaraes, R.C. (2002).A systematic concept of the gene. *Genet molBiol, 15*: 713-721.

Petty, G. (2009). *Teaching Today a Practical Guide (4thed.)* Cheltenham Nelson Thornes Ltd.

Piaget, J. (2000). *The construction of reality in the child*. New York. Basic books.

Portin, P. (2009). *The elusive concept of the gene. Hereditas* 146:112 – 117. (pubmed).

Prosser, M., & Trigwell, K. (1997), "Relations between perceptions of the Teaching environment and Approaches to Teaching" *British Journal Educational Psychology, 67, 25-35.*

Rockmore, T. (2011). *Kant and Phenomenology*. Chicago, IL: University of Chicago press.

Saka, A., Cerrah, L., Akdeniz, A.R., &Ayas, A. (2006). A cross-age study of the understanding of three genetics concepts: How do they image the gene, DNA, and chromosome? *Journal of Science Education and Technology,15(2),* 192-202. doi: 10.1007/s 10956-006-9006-6.

Santos, V. C., Joaquium, L. M., & El-Hani, C. N. (2011). Hybrid deterministic views about genes in biology textbook: A key problem in genetics teaching. *Science & Education, 21(4),* 543-578. doi: 10.1007/s 1119-0119348-1.

Schwandt, T.A. (1997). *Qualitative inquiry*: *A dictionary of terms*. Thousand oaks', CA: Sage.

Sesli, E., & Kara, Y. (2012).Development and application of a two-tair multiple-choice diagnostic test for high school students' understanding of all division and reproduction.*Journal of Biology Education, 46(4),* 214-225. doi:10.1080/002/9266.2012.688349.

Unal, R. and Zoldman, D.A. (1990). STUDENTS' DESCRIPTION OF Atom: Aphenomenographic Analysis. Retrieved on November 1, 2018, From: *https://www.researchgate.net/publciation/228899849_students'_description_of_an_atom_A_phenomenographic analysis.*

Van Manen, M. (1990).*Researching lived experience: Human science for an action sensitive pedagogy.* New York, NY: SUNY Press.

Van Manen, M *(1997) Phenomenological Pedagogy and the Questions of Meaning in Vanderberg, D (Ed.) Phenomenology & Education Discourse* (41 – 68). Johannesburg, South Africa: Heinemann

Vygotsky, L.S. (2008). Students perceptions of inclusion and resource room setting. *The journal of special ducaiton, vol. 32(2).*79-88.

WAEC (2013).*Official results for 2013*, Yaba Lagos.

Wang, S.H; Simcox, A.; Cambell, G. (2000). *Dual role for Drosophita epidermal growth receptor signaling in early wing disc development*. Genes Dev. 14 (18); 2271-2276.

Williamson, K. (2006). *Research in constructivist frameworks using ethnographic.*Farming ton hills. Michigan. Gale group.

Wilson, C. D., Anderson, C. W., Heideman, M., Merrill, J. E., Merritt, B. W., Richmond, G., parker, J. M. (2006).Assessing students' ability to trace matter in dynamic system in cell biology. *CBE Life Sci. Educ., 5(4),* 323-331. Dio:10.1187/cbe.06-02-0142.

Wood-Robinson, C. &Laewis, J. (2000).Young people's understanding of the nature of genetic information in the cell of an organisms. *Journal of biological education, 35(1),* 29-36.

Wood-Robinson, C. (2000). Young people's ideas about inheritance and evolution.*Stud. Sci. educ, 24*, 29-47.

Wright, L.K., Fisk, J.N., Newman, D.L. (2014). DNA to RNA: What do Students think The Arrow Means? Campbell AM, ed. *CBE Life Science education, 13(2):* 338-348. dio: 10.1187/cbe.CBE-13-09-0188.