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EVALUATING STUDENTS' MISCONCEPTIONS OF PHOTOSYNTHESIS AND RESPIRATION IN A GHANAIAN SENIOR HIGH SCHOOL

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ABSTRACT
The study investigated Senior High School (SHS) students' conception of photosynthesis and respiration**.** The population consisted of Three hundred and five (305) SHS students from two schools in the Abura-Asebu Kwamankese district in the Central Region of Ghana. The sample was made up of one hundred and fifty-five students (155) from Aggrey Memorial SHS and one hundred and fifty (150) students from Aburaman SHS. The instrument for collecting data was a 19-item self-structured validated questionnaire that yielded scores on a four-point scale, with an internal consistency of .572 Cronbach alpha values. Data collected were analysed using frequency counts and percentages. The results gathered from the study showed that 31.5% of students did not know that glucose is the raw material for cellular respiration, and that water is produced as a by-product in aerobic respiration. Likewise, 23.6% and 29.9% of the respondents said Adenosine Tri-phosphates (ATPs) are not released at the end of aerobic respiration, and that anaerobic respiration does not occur in both plants and animals respectively. It also came to light that 36.7% of the respondent did not know that anaerobic respiration does not require oxygen for the reaction to proceed.

KEYWORDS: Photosynthesis, respiration, misconception, conception.

INTRODUCTION

Overcoming misconceptions is crucial to students learning. Challenging misconceptions and providing students with opportunities to re-construct their world-view, help improve students' use of science conceptions to explain phenomena (Fisher & Wandersee, 2001). Many studies in science education have focused on students' misconceptions in the area of biology, especially those related to photosynthesis and respiration. Studies of students from age 11 to college age indicate that students hold similar misconceptions about photosynthesis regardless of the amount of science instructions they have received (Amir & Tamir, 1994; Anderson, Sheldon & Dubay, 1990; Canal, 1999; Eisen & Stavy,1988; Eisen & Stavy, 1992; Waheed & Lucas, 1992). Mikkila-Erdmann (2001) investigated the effect of conceptual change texts on understanding of photosynthesis by 5th grade students. As a result of this researchers have realised that conceptual change texts have an important bearing on photosynthesis, especially on students who have insufficient previous knowledge. Research reveals about misconceptions are hard to eliminate through traditional approaches (Tekkaya, Capa & Yelmaz, 2000). Cepni *et al*., (2006) carried out a study to reveal cognitive development, misconceptions and attitudes of students about the concept of photosynthesis. They concluded that, making use of the Computer-Assisted Instruction Material (CAIM) was very crucial for attaining the application and comprehension levels in teaching photosynthesis. However, they observed that CAIM did not substantially change the misconceptions of students about photosynthesis. Köse *et al*., (2006) observed that most of pre-service teachers had misconceptions about photosynthesis and respiration in plants. The author concluded that concept-changing texts were efficient in comprehension of photosynthesis and respiration in plants and in the reduction of misconceptions of pre-service teachers.

Tekkaya and Balci (2003) determined the misconceptions of high school students on the concept of photosynthesis and respiration in plants and concluded that most students had the idea that photosynthesis was a gas alternation process, and that energy was produced after photosynthesis, and that photosynthesis was the reverse of respiration which according to the researchers was scientifically invalid.

A particularly widely held misconception that relates to photosynthesis was the belief that plants got their food from the soil, even after studying photosynthesis. Perhaps this occurs because instructions about photosynthesis tend to focus on the gas exchange (plants take in carbon dioxide and give off oxygen) rather than on carbohydrate production. This is understandable, as photosynthesis is a challenging topic to teach, particularly to students with little or no prior instruction in chemistry. A study of the prerequisite concepts required for understanding photosynthesis suggests that students may not be able to distinguish between common gases such as carbon dioxide and other compounds, such as carbohydrates (Simpson & Arnold, 1982). In addition to this confusion about gases, studies indicate that students, even some with over a year of prior biology instruction do not know what plants use for food. Most view food for plants as substances the plants take from their environment (Anderson *et al*., 1990; Roth, Smith & Anderson, 1983).

With so much confusion about gases and food, it is not surprising that students also have difficulty understanding the energy transformations that are critical to understanding photosynthesis. Studies have shown that many students view light as a reagent in the photosynthetic process rather than as the energy source that is required to initiate the process (Anderson *et al*., 1990; Barker & Carr, 1989; Eisen & Stavy, 1988; Roth *et al*., 1983). Thus, students may begin a study of photosynthesis with misconceptions that will be obstacles to their truly understanding the process.

Again, Capa, Yildirim and Ozden (2001) investigated students' misconceptions concerning photosynthesis and respiration in plants, and found these misconceptions to be generally based on social practices and school experiences involving students' learning styles and instruction. Anderson *et al*. (1990) used a written pretest administered to 105 university students enrolled in a biology course for non majors to investigate students' understanding of photosynthesis and respiration. They found most students indicated that food for plants, like food for animals, is taken from the environment. Only 2% of the students responded that plants take in food through their roots. Overall, 86% of the students could not provide correct definitions of what constitutes food for a bean plant. This should not be surprising, though, as 75% could not provide acceptable functional definitions of what constitutes food for a person. Biology students of Aggrey Memorial SHS have misconceptions about photosynthesis and respiration. But the concepts run through Primary School, Junior High School (JHS), and SHS syllabuses as well as those of tertiary institutions and the inability of students to have the correct basic concepts of photosynthesis and respiration at the SHS level makes students have difficulties in grasping the higher concepts in photosynthesis and respiration at the tertiary levels.

The study therefore explores some of the misconceptions that students of Aburaman and Aggrey Memorial SHS have about photosynthesis and respiration, which do not help them to understand the basic concepts as they progress to the tertiary levels of education in Ghana.

Research Questions

Students' conceptions about photosynthesis and respiration in Aburaman and Aggrey Memorial Senior High Schools were examined with the following questions:

1. What conceptions do students have about photosynthesis?
2. What conceptions do student have about respiration?

METHODOLOGY

The descriptive survey was explored to find SHS students' conceptions of photosynthesis and respiration. The accessible population comprised two selected SHSs in the Abura Asebu Kwamankese in the Central Region of Ghana. A sample size of three hundred and five (305) students was selected from the two (2) SHSs; one hundred and fifty (150) and one hundred and fifty five (155) students were randomly sampled from both Aburaman and Aggrey Memorial SHSs respectively. A questionnaire was used in collecting the data, and each item was scored using a four-point Likert Scale [strongly disagree (SD), Disagree (D), Agree (A) & strongly agree (SA)]. The first part of the questionnaire surveyed student's conception about photosynthesis while the other section elicited student's conception about respiration.

The questionnaire items were given a thorough examination to ensure that they measured the total content area of the study. This was done to ensure face and content validity of the items. A pilot test of the instrument was carried out on twenty (20) SHS 4 biology students at Assin Manso Senior High School in the Central Region of Ghana. The students used for the pilot test, did not form part of the sample for the study. A Cronbach's alpha was determined on the data gathered using Statistical Package for Social Sciences (SPSS) software version seventeen (17). The output gave alpha coefficient of reliability of .572, which according to Bowling (1997) is an indication of good internal consistency. Frequency counts, percentages and graphs were used to analyse the questionnaire consisting of seven items on photosynthesis and twelve items on respiration.

RESULTS

The data collected from the questionnaire were organised into two subsections (photosynthesis and respiration respectively) based on the research questions. The first part presents the results of descriptive analysis on the conceptions students have about photosynthesis as a concept, and the second on respiration also as a concept.

ANALYSIS OF FINDINGS

Research Question 1

What conceptions do students have about photosynthesis?

This subsection presents the result of analysis on the conceptions students have about photosynthesis. Tables 1-7 present the frequency and percentages of different items on conceptions students have about photosynthesis.

Item 1: This item assesses whether students know carbon dioxide and water are the main raw materials for photosynthesis (Table 1).

TABLE 1: Carbon dioxide and water as the main raw materials for photosynthesis

Level of Agreement	Frequency	Percentage (%)
Strongly Disagree	28	9.2
Disagree	46	15.1
Agree	116	38.0
Strongly Agree	115	37.7
Total	305	100

From Table 1, 75.7% strongly confirmed that carbon dioxide and water are the main raw materials for photosynthesis. However, the remaining 24.3% did not agree that carbon dioxide and water were the main raw materials. Although, majority of the students agree to the statement, there is a clear indication that 24.3% of respondents have misconceptions about the raw materials for photosynthesis.

Item 2

This item displays whether glucose is the major product of photosynthesis. As shown in Table 2, 79.7% of the participants agreed that glucose was the major product of photosynthesis. However 19.6% disagreed with the statement. Again, 0.7% did not respond to the statement in the Table 2.

TABLE 2: Glucose as the major product of photosynthesis

Level of Agreement	Frequency	Percentage (%)
No Response	2	0.7
Strongly Disagree	23	7.5
Disagree	37	12.1
Agree	97	31.8
Strongly Agree	146	47.9
Total	305	100

Item 3

Did participants know that oxygen was a by-product at the end of photosynthesis?

TABLE 3: Oxygen as by-product of photosynthesis

Level of Agreement	Frequency	Percentage (%)
Strongly Disagree	8	2.6
Disagree	13	4.3
Agree	96	31.5
Strongly Agree	188	61.6
Total	305	100

In Table 3, majority of the respondent, 93.1% were of the view that oxygen is a by-product of photosynthesis. Nevertheless, the remaining 6.9% said oxygen was not produced as a by-product of photosynthesis.

Item 4

This illustrates respondents' level of agreement and disagreement on whether chloroplasts are found only in the green parts of plants as indicated in the Table 4.

TABLE 4: Chloroplasts only in the green parts of plants

Level of Agreement	Frequency	Percentage (%)
No Response	3	1.0
Strongly Disagree	22	7.2
Disagree	65	21.3
Agree	94	30.8
Strongly Agree	121	39.7
Total	305	100

Seventy point five per cent (70.5 %) of respondents agreed that chloroplasts were found only in the green parts of plants, while 28.5% were of the view that chloroplasts are not found in the green parts of plants only. The remaining 1% did not comment on the statement as shown in the Table 4.

Item 5

Are chloroplasts the green pigments of chlorophyll?

TABLE 5: Chloroplast as the green pigment of chlorophyll

Level Agreement	Frequency	Percentage (%)
No Response	1	0.3
Strongly Disagree	8	2.6
Disagree	16	5.2
Agree	105	34.4
Strongly Agree	175	57.4
Total	305	100

According to Table 5, 91.8% agreed that chloroplasts contain the green pigment, chlorophyll. On the other hand, 7.8% disagreed to the statement with 0.3% remained neutral to the statement.

Item 6

Students' responses to Item 6 are summarized in the Table 6.

TABLE 6: Light energy is absorbed by chlorophyll in photosynthesis

Level of Agreement	Frequency	Percentage (%)
No Response	1	0.3
Strongly Disagree	6	2.0
Disagree	10	3.3
Agree	106	34.8
Strongly Agree	182	59.7
Total	305	100

In Table 6 94.8% agreed that chlorophyll absorbed energy in sunlight for photosynthesis. On the contrary, 5.5% of the respondents disagreed that chlorophyll absorbed energy in sunlight for photosynthesis. Zero point three per cent (0.3%) of the respondents were silent on the statement.

Item 7

Holophytic organisms are organisms that use light energy for the synthesis of food.

TABLE 7: Light energy is used for the synthesis of food by holophytic organisms

Level of Agreement	Frequency	Percentage (%)
No Response	3	1.0
Strongly Disagree	26	8.5
Disagree	52	17.0
Agree	122	40.0
Strongly Agree	102	33.4
Total	305	100

In Table 7, 73.7% of the respondents agreed that holophytic organisms use light energy for the synthesis of food. Conversely 25.5% of the respondents refuted the statement that holophytic organisms used light energy for the synthesis of food. The remaining 1% did not respond to the statement in the Table 7.

Research Question 2

What conceptions do student have about respiration?

This subsection presents the result of analysis on the conceptions students have about respiration as a concept. Figures 1-12, present the percentages of different items on the conceptions students have about respiration as a concept.

Item 1: Glucose is the main substance used in respiration (Fig. 1)

In Fig. 1, 67.2% of the respondents agreed that glucose was the main raw material for respiration, while 31.5% disagreed. On the other hand, 1.3% did not respond to the statement.

Item 2: Oxygen is the principal substance required in aerobic respiration (Fig. 2)

As demonstrated in Fig. 2, majority of the respondents agreed that aerobic respiration required oxygen for the reaction to proceed, while 5.6% disagreed with the statement. However, 1.6% did not comment on the statement.

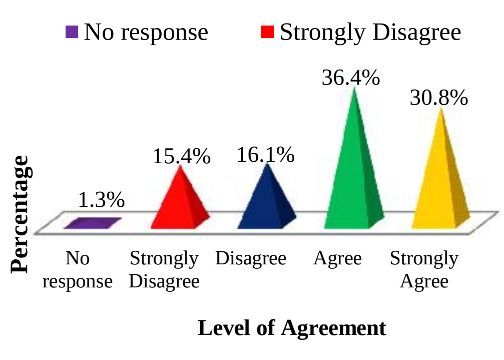


FIGURE1: Glucose as the main raw material for respiration

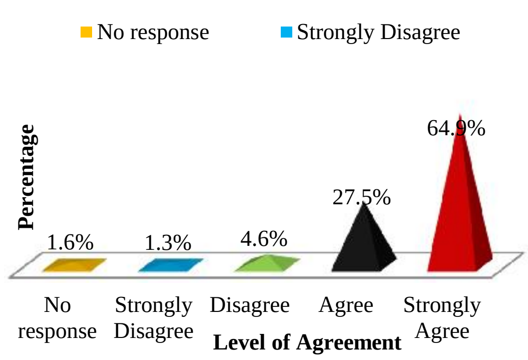


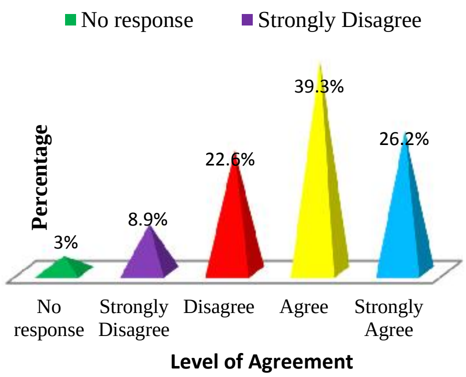
FIGURE 2: Oxygen as a reactant in aerobic respiration

Item 3: Water is produced as a by-product in aerobic respiration (Fig. 3)

To this statement, 65.5% of the respondents supported the statement, while 45% disagreed with the statement. The rest numbering 3% did not respond to the statement.

Item 4: ATPs are released at the end of aerobic respiration (Fig. 4)

To this statement, 72.8% of respondents agreed, while 23.6% disagreed with the remaining 3.6% silent on the statement.



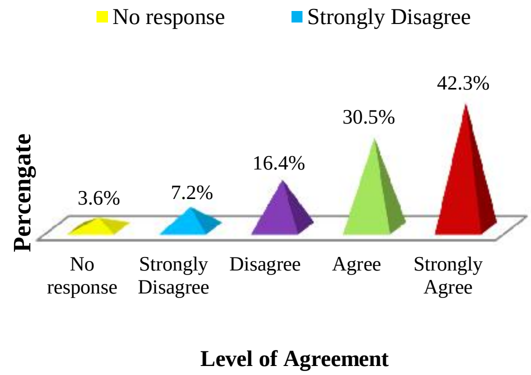


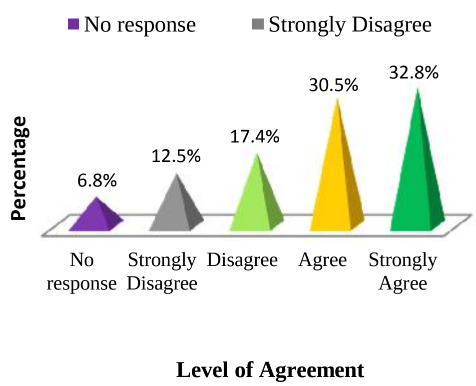
FIGURE 3: Water as the by-product of aerobic respiration **FIGURE 4:** ATPs as major product of aerobic respiration

Item 5: Anaerobic respiration occurs in both plants and animals (Fig. 5)

In Fig. 5, 63.3% of the respondents agreed to the statement, while 29.9% disagreed that anaerobic respiration occurs in both plants and animals with 6.8% of the respondents not commenting on the statement.

Item 6: Anaerobic respiration requires for the reaction to proceed (Fig. 6)

To this statement 35.7% of the respondents agreed, while 59.7% of them disagreed to the statement. The remaining 4.6% did not comment on the statement.



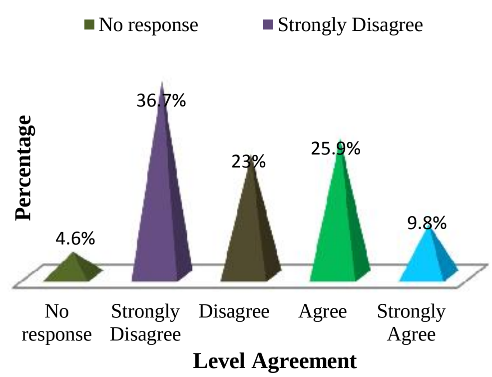


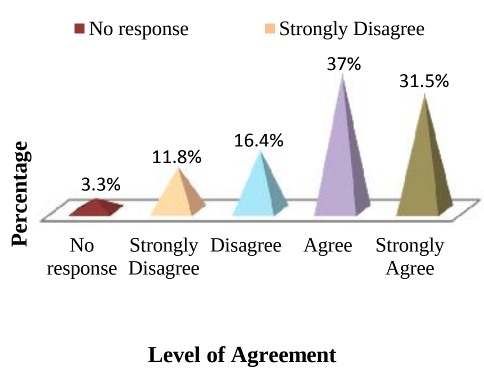
FIGURE 5: Anaerobic respiration in both plants and animals **FIGURE 6:** Oxygen for anaerobic respiration to proceed

Item 7: ATPs are released at the end of anaerobic respiration (Fig. 7)

According to Figure 7, 68.5% of the respondents agreed, while 28.2% disagreed. The rest numbering 3.3% respondents did not respond to the statement.

Item 8: Products of anaerobic respiration in animals (Fig. 8)

In Fig. 8, 71.1% of the respondents were of the view that ethanol is one of the products of anaerobic respiration in animals. However, 26.7% of the respondents did not agree with 2% commenting on the statement.



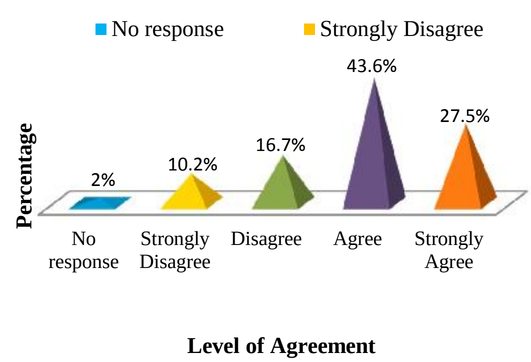


FIGURE 7: ATPs as major product of anaerobic respiration **FIGURE 8:** Ethanol as a product of anaerobic respiration in animals

Item 9: Lactic acid is one of the products anaerobic respiration in animals (Fig. 9)

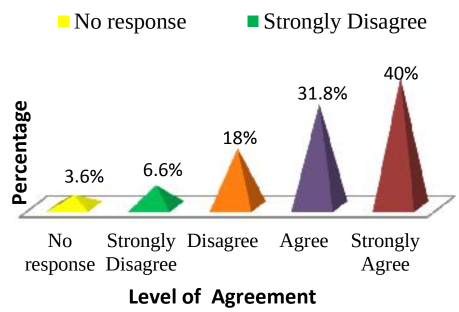
In Fig. 9, 71.8% of the respondents agreed that lactic acid is one of the products of anaerobic respiration in animals, while 24.6% disagreed with 3.6% not responding to the statement.

Item 10: Much energy is released in aerobic respiration (Fig. 10).

To the statement 86.6% agreed while 10.2% disagreed with 3.3% not responding to the statement.

Item 11: Oxygen is required in anaerobic respiration (Fig. 11)

As illustrated in Figure 11, 63.6% of the respondents agreed while 34.1% were of the view that oxygen is required with the remaining 2.3% not commenting on the issue.



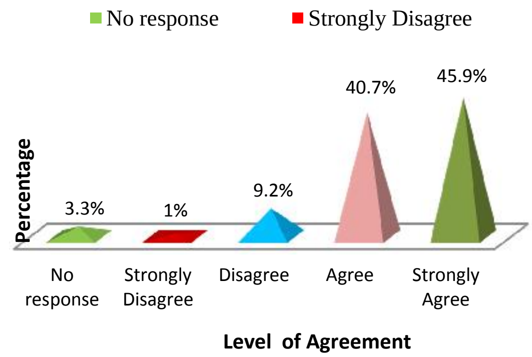


FIGURE 9: Lactic acid as a product of anaerobic respiration in animals **FIGURE 10:** Energy as a major product of aerobic respiration

Item 12: Energy released during respiration is used in many life activities such as active transport of substances in and out of cells (Fig. 12)

In Figure 12, 93.4% of the respondents agreed with the view while only 4.9% disagreed with 1.6% not responding to the statement.

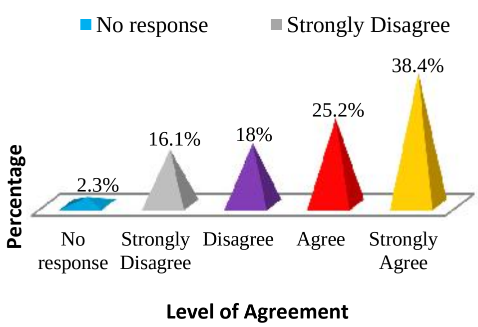


FIGURE 11: O_2 not a requirment in anaerobic rspiration

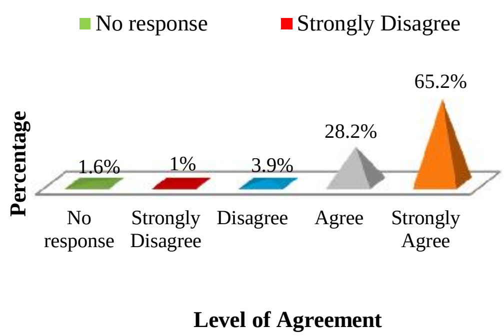


FIGURE 12: Energy used for active transport of substance

DISCUSSION

The findings of the study were critically analysed with reference to the relevant literature in an attempt to come out with the meanings of the responses, and to identify the issues and the underlying phenomenon. It was found that majority of the students had sound understanding of the photosynthesis with few misconceptions. In conclusion, Anderson *et al*. (1990), Eisen and Stavy (1988), and Roth, Smith and Anderson (1983) reported that majority of the students could not mention how beans are produced during photosynthesis with majority not knowing the sun as the source of energy for plants.

Also minority view oxygen as a requirement in anaerobic respiration and consider ethanol as a product in animals. This affirms that students examined had misconceptions because anaerobic respiration proceeds without oxygen and ethanol is a product of anaerobic respiration in plants and not in animals. Likewise, Songer and Mintzes (2006) confirmed that many novices harbour wide range of conceptual difficulties that constrains their understanding of cellular respiration. Many of these difficulties persist even after delivery of instructions. Often these conceptual problems remain intact among experienced students despite well-planned and repeated instructions at advanced levels (Songer & Mintzes, 2006; TNSCLS, 2007).

CONCLUSIONS

In concluding, teachers' must change from being presenters of information to facilitators in the teaching and learning process to assist students in forming scientifically accurate concepts. Teachers should identify students' prior knowledge before instructions, and put an end to the use of traditional methods of teaching, and adopt other instructional methods to enable students overcome misconceptions. However, innovative techniques and models of science instruction must be practised by teachers, such as cooperative learning strategies, inquiry training model, web-quest, stimulation games, etc.

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