IMPROVING 8th GRADE STUDENTS' UNDERSTANDING OF PHOTOSYNTHESIS AND RESPIRATION IN PLANTS BY USING 5E LEARNING CYCLE AND CONCEPTUAL CHANGE TEXT

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Approval of the Graduate School of Natural and Applied Sciences

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

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The purpose of this study was to investigate the effects of 5E learning cycle, conceptual change texts and traditional instruction on 8th grade students' understanding of photosynthesis and respiration in plants. Besides, the effect of instruction on students' attitudes toward science as a school subject was investigated.

One hundred and one, 8th grade students from three classes of one elementary school in Ankara attended in this study. This study was carried out during the fall semester of 2003-2004 academic year. The classes were randomly assigned as control and experimental groups. Students in the first experimental group (n=33) received 5E learning cycle based instruction, the second experimental group (n=34) received conceptual change text based instruction and students in the

control group (n=34) received traditional instruction. Two-tier multiple-choice diagnostic test, “Photosynthesis and Respiration in Plants Concept Test”, was used to determine students’ understanding of photosynthesis and respiration in plants. The test was administered to the sample of the study as pre- and post-test. Students’ attitudes toward science and their reasoning abilities were measured by “Attitude Scale Toward Science” and “Test of Logical Thinking” respectively.

The hypotheses of the study were tested by using analysis of covariance (ANCOVA). The results indicated that there were significant differences among the treatment groups with respect to their understanding of photosynthesis and respiration in plants. Both 5E learning cycle based instruction and conceptual change text based instruction were found effective to eliminate 8th grade students’ misconceptions about photosynthesis and respiration in plants. The results also showed that there were no significant differences among the treatment groups with respect to attitudes toward science as a school subject.

Keywords: 5E learning cycle, conceptual change text, photosynthesis, respiration in plants, misconceptions.

ÖZ

8. SINIF ÖĞRENCİLERİNİN FOTOSENTEZ VE BİTKİLERDE SOLUNUM KAVRAMLARINI ÖĞRENİMİNİN 5E ÖĞRENME MODELİ VE KAVRAMSAL DEĞİŞİM METİNLERİ KULLANILARAK GELİŞTİRİLMESİ

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Bu çalışma, 5E öğrenme modelinin, kavramsal değişim metinlerinin ve geleneksel öğretim yönteminin 8. sınıf öğrencilerinin fotosentez ve bitkilerde solunum konularındaki kavram yanılgılarını düzeltmedeki etkisini araştırmak amacıyla yapılmıştır. Aynı zamanda, öğretim yöntemlerinin öğrencilerin fen bilgisi dersine yönelik tutumlarına etkisi de araştırılmıştır.

Bu çalışma, Ankara' da bir ilköğretim okulunun üç ayrı sınıfında bulunan 101 sekizinci sınıf öğrencisi ile 2003-2004 eğitim yılının güz döneminde yapılmıştır. Sınıflar kontrol grubu ve deney grupları olarak rasgele seçilmiştir. Birinci deney grubundaki öğrenciler (n=33) dersi 5E öğrenme modeli ile işlerken, ikinci deney grubundaki öğrenciler (n=34) kavramsal değişim metinlerine dayalı öğretim yöntemi ile, kontrol grubundaki öğrenciler (n=34) ise geleneksel öğretim yöntemi

ile işlemişlerdir. Öğrencilerin fotosentez ve bitkilerde solunum konularındaki kavram yanılgılarını bulmak için iki aşamalı tanı testi, "Fotosentez ve Bitkilerde Solunum Kavram Testi", kullanılmıştır. Bu test bütün gruplara ön-test ve son-test olarak uygulanmıştır. Ayrıca, öğrencilerin fen bilgisi dersine karşı tutumlarını ve mantıksal düşünme yeteneklerini ölçmek için sırasıyla "Fen Bilgisi Dersi Tutum Ölçeği" ve "Mantıksal Düşünme Yetenek Testi" bütün gruplara uygulanmıştır.

Araştırmanın hipotezleri ortak değişkenli varyans analizi (ANCOVA) kullanılarak test edilmiştir. Sonuçlar deney gruplarının fotosentez ve bitkilerde solunum konularını anlamada kontrol grubundan daha başarılı olduğunu göstermiştir. Hem 5E öğrenme modeline dayalı öğretim yöntemi hemde kavramsal değişim metinlerine dayalı öğretim yöntemi 8. sınıf öğrencilerinin fotosentez ve bitkilerde solunum konularında sahip oldukları kavram yanılgılarını gidermede etkili olmuştur. Sonuçlar ayrıca deney ve kontrol grupları arasında öğrencilerin fen bilgisi dersine karşı tutumları açısından anlamlı bir fark olmadığını göstermiştir.

Anahtar kelimeler: 5E öğrenme modeli, kavramsal değişim metni, fotosentez, bitkilerde solunum, kavram yanılgıları.

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LIST OF SYMBOLS

EG **:** Experimental Group

CG **:** Control Group

5E-LCBI : 5E Learning Cycle Based Instruction

CCTBI **:** Conceptual Change Text Based Instruction

TI **:** Traditional Instruction

TOLT **:** Test of Logic Thinking

PRPCT **:** Photosynthesis and Respiration in Plants Concept Test

ASTS **:** Attitude Scale toward Science

df **:** Degrees of freedom

SS **:** Sum of squares

MS **:** Mean square

$\overline{X}$ **:** Mean of the sample

P **:** Significance level

F : F statistics

CHAPTER 1

INTRODUCTION

"If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows." (Ausubel, 1968, p.335).

Learning starts from the birth and occurs in every day of human life. Children learn concepts from many sources; parents, siblings, television, radio, CD, books, computers, museums, zoos etc. Before formal schooling, children construct their own explanations with their everyday experiences. Consequently, children do not enter the classrooms as blank slates, but they enter classrooms with a preexisting knowledge of science concepts (Posner, Strike, Hewson & Gertzag, 1982). Students' preexisting knowledge may be incorrect, incomplete or ineffective to explain the scientific phenomena. Students' conceptions which are inconsistent with the ideas of scientists have been called "misconceptions" (Fisher, 1985), "alternative conceptions" (Arnaudin & Mintzes, 1985), "naive theories" (Mintzes, 1984), or "children science" (Gilbert, Osborne & Fensham, 1982). The term "misconception" will be used throughout this study to define students' ideas that are in conflict with those generally accepted by scientists.

For three decades students' understanding of natural phenomena has become focus of science education studies. Many of the research studies have focused on students' difficulties to conceptualize; growth, reproduction and transport mechanisms (Okeke & Wood-Robinson, 1980), natural selection (Bishop &

Anderson, 1990), evolution (Deadman & Kelly, 1978), genetics (Cavello & Shafer, 1994; Kargbo, Hobbs & Erickson, 1980), respiration (Alparslan, Tekkaya & Geban, 2003; Sanders, 1993; Seymour & Longden, 1991; Songer & Mintzes, 1994; Tekkaya, Özkan & Aşçı, 2001), amino acids and translation (Fisher, 1985), human circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001), diffusion (Westbrook & Marek, 1991), diffusion and osmosis (Odom & Barrow, 1995), food web (Griffiths & Grant, 1985), ecological concepts (Adeniyi, 1985; Özkan, Tekkaya & Geban, 2004), photosynthesis and respiration in plants (Amir & Tamir, 1994; Anderson, Sheldon & Dubay, 1990; Barker & Carr 1988a, b, 1989; Eisen & Stavy; 1988; Haslam & Treagust, 1987; Hazel & Prosser, 1994; Seymour & Longden, 1991; Smith & Anderson, 1984; Stavy, Eisen & Yaakobi, 1987; Tekkaya & Balcı, 2003; Waheed & Lucas, 1992). Many of these concepts about which students hold misconceptions are basic to science knowledge and are interrelated. Concepts related to photosynthesis and respiration in plants are among such concepts; students' understanding of photosynthesis and respiration in plants influence their understanding of food chains, food webs, carbon cycle, plant structure and function, how digestive systems, circulatory systems, and respiratory systems function and how the world functions as an ecosystem.

Misconceptions affect further learning negatively. They are pervasive, stable and resistant to change (Driver & Easley, 1978; Fredette & Lockhead, 1980; Haslam & Treagust, 1987; Osborne, 1983). If the misconceptions are not corrected, new learning can be encumbered or it might not take place at all. To promote learning, methods to eliminate misconceptions must be found. Research studies consistently showed that traditional methods are not effective to enhance students' understanding of scientific concepts (Adeniyi, 1985; Anderson & Smith, 1987, Bishop & Anderson, 1990; Driver, 1983; Fisher, 1985; Haider & Abraham, 1991; Lumpe & Staver, 1995; Tobias, 1990). Constructivist approach represents an alternative approach to encourage students to change misconceptions. According to constructivist approach; for learning to occur,

student should relate newly learned concepts to his already existing knowledge. Links should be constructed between the existing concepts and the new concepts through experience (Gilbert, Osborne & Fensham, 1982). Students should be active and be involved in the learning process. Thus, knowledge from a textbook or a teacher cannot be transmitted to the student's mind. Teachers should take the prior knowledge of students' into account, for the instruction have chance to overcome students' misconceptions. They should provide a learning environment that gives the students the opportunity to relate what they are learning to what they already know. So, students will have the opportunity to evaluate the ideas they have, decide to change the existing concepts with the new ones, modify the existing ones or continue to believe the existing concepts (Wheatley, 1991). Thus, it can be said that learning is a process of conceptual change. Conceptual change theory states that, students should become dissatisfied with their existing conditions to change their ideas (dissatisfaction), new concepts should provide better explanation (intelligibility), new concepts should propose solutions to problems (plausibility), and they must lead to new insights (fruitfulness) (Posner, Strike, Hewson & Gertzog, 1982).

There are several instructional techniques and instructional tools that promote conceptual change such as; concept maps (Novak, 1990; Wallace & Mintzes, 1990), bridging analogies approach (Brown & Clement, 1989) and conceptual change texts (Alparslan, Tekkaya & Geban, 2003; Chambers & Andre, 1997; Mikkilä-Erdmann, 2001; Özkan, Tekkaya & Geban, 2004; Sungur, Tekkaya & Geban, 2001; Wang & Andre, 1991). Conceptual change texts are one of the effective conceptual tools in science education. They are prepared according to Posner et al.'s (1982) four conditions; dissatisfaction, intelligibility, plausibility and fruitfulness. Conceptual change texts start with a question, and then students' misconceptions are presented. This action activates students' misconceptions. Then scientific explanations of the concepts supported by examples are given to students. Conceptual change texts are supplementary documents for classroom instruction.

Learning cycle is another instructional technique based on the constructivist approach and promotes conceptual change (Stepans, Dyvhe & Beiswenger, 1988). It is derived from Piaget's mental functioning model (Abraham, 1989; Purser & Renner, 1983; Renner, Abraham & Birnie, 1988; Scharmann, 1991) and developed by Robert Karplus with the Science Curriculum Improvement Study (SCIS) in 1964. Karplus' learning cycle consists of three phases; exploration, term introduction and concept application. As the learning cycle has been used and researched over the years it is revised and 5E learning cycle is formed. It is developed by the BSCS group (Biological Sciences Curriculum Study) and consists of five phases; engagement, exploration, explanation, elaboration and evaluation.

As it is mentioned, students have misconceptions about photosynthesis and respiration in plants and these misconceptions influence their further learning negatively. Therefore instructional strategies that will eliminate students' misconceptions should be applied in classroom situations. For this reason, in the present study, we concerned with students' misconceptions about photosynthesis and respiration in plants and instructional methods to improve students' understanding of photosynthesis and respiration in plants. This study investigates the effects of three instructions; 5E learning cycle based instruction (5E-LCBI), conceptual change text based instruction (CCTB) and traditional instruction (TI) on 8th grade students' understanding of photosynthesis and respiration in plants. Also, the effect of instruction on students' attitudes toward science as a school subject is also investigated in this study.

Significance of the Study

To eliminate students' misconceptions related with photosynthesis and respiration in plants several methods are used. There are lots of research studies related with the misconceptions about these two concepts. Conceptual change text based instruction is mostly studied as one of the ways to eliminate students'

misconceptions. However, the effects of 5E-LCBI on students' understanding of photosynthesis and respiration in plants are rarely studied. Also there are not many studies that compare the effects of three instructions on students' misconceptions in the literature. This study aims to fill these gaps in the literature.

This research study will be interest of teachers, curriculum designers, curriculum developers and other researchers. It will present an example for incorporating 5E-LCBI and CCTBI to photosynthesis and respiration in plants concepts. This study will provide some information about 5E-LCBI and CCTBI, how they can be applied into the classroom situation, and their effects on students' misconceptions about photosynthesis and respiration in plants and their effects on students' attitudes toward science as a school subject.

CHAPTER 2

REVIEW OF LITERATURE

Children learn many concepts from various sources before formal schooling. Whether learning occurs through formal schooling or not, restructuring of ideas and beliefs take place in the learning process. Piaget researched how children learn about the world and has provided important contributions to the understanding of children's thinking. Piaget (1969) called the preexisting knowledge of the learner as "schemata" and he explained that a learner is constantly trying to define the world around him with the existing schemata. According to Piaget, if the learner is able to explain the events occurring around him correctly, then it can be said that he has reached the state of equilibrium. If the learner cannot explain the new experience with the existing schemata, then disequilibrium occurs. At this situation, new information is added to the existing schemata; or the existing schemata are adjusted in order to accommodate the new information. A misconception can occur if the learner cannot link the new experience with the existing schemata, so the learner adapts similar schemata to fit the new information (Eggen & Kauchak, 1994). Or misconception can occur if a student connects wrong information to existing schemata. If the misconception is not corrected, new learning might not take place (Brown, 1992).

2.1 Addressing Misconceptions

Misconceptions, defined as the students' ideas about natural phenomena that are inconsistent with scientific conceptions, are said to be pervasive, stable and often resistant to change through traditional teaching methods (Amir & Tamir, 1994; Fisher, 1985; Westbrook & Marek, 1991). To correct misconceptions we should firstly identify them. Interviews (Arnaudin & Mintzes, 1985; Fisher, 1985;

Lawson, 1988; Odom & Borrow, 1995; Songer & Mintzes, 1994; Sungur, Tekkaya & Geban, 2001) and concept maps (Arnoudin & Mintzes, 1985; Okebukola, 1990; Songer & Mintzes, 1994; Sungur, Tekkaya & Geban, 2001), have acquired strong support as successful methods to determine students' understanding of science concepts. However, these methods have several limitations for use by classroom teachers. Interviews require large amounts of time to conduct, transcribe, and interpret. Concept maps require teacher training for scoring and interpretation. Using two-tier multiple-choice diagnostic test is another way to identify misconceptions. It is easy to administer and score, so it is mostly used to determine students' misconceptions. (Alparslan, Tekkaya & Geban, 2003; Haslam & Treagust, 1987; Odom & Barrow, 1995; Özkan, Tekkaya & Geban 2004; Rollnick & Mahooana, 1999; Seymour & Longden, 1991)

In order to eliminate students' misconceptions, it is necessary to identify the sources of these misconceptions. During the learning process, the student tries to link new knowledge with the existing one. If the student holds several misconceptions, he cannot connect the new knowledge to his existing schemata and new learning might not take place (Nakleh, 1992). So, it can be said that students' existing ideas are important factors that affect the development of misconceptions. Yip (1998) stated that "everyday experiences", "unscientific use of language", "misunderstanding or lack of understanding of the concepts during lessons" and "inaccurate teaching" affects the formation of misconceptions. Çapa (2000) found that school experiences caused ninth graders' misconceptions about photosynthesis and respiration in plants. Taber (1995) stated that teachers may also cause misconceptions. According to De Pasada (1999) and Hurst (2002) textbooks might be one of the sources of misconceptions, since they are used more than any other educational material; they may affect students' learning.

2.1.1 Misconceptions Related to Photosynthesis and Respiration in Plants Concepts

Previous studies concerning teaching of photosynthesis and respiration in plants concepts showed that they are among the most important topics and the most difficult for students to understand. These concepts are fundamental biological processes and understanding these processes is essential to understanding many other concepts in biology. Amir and Tamir (1994) stated that photosynthesis is one of the most important biological topics and it is taught at different grade levels. A similar finding is reported by Hazel and Prosser (1994). Eisen and Stavy (1988) mentioned that understanding of photosynthesis is important for a basic understanding of how the world functions as an ecosystem. Anderson, Sheldon and Dubay (1990, p.761-762) described why they have studied these concepts and the importance of them as following:

> We chose to focus on the related processes of respiration and photosynthesis because of their curricular significance. For example, our digestive systems, circulatory systems, and respiratory systems all function as they do largely because of the needs of our body cells to engage in respiration. Similarly, the demands of photosynthesis dictate many characteristics of plant structure and function. Even more important, an understanding of photosynthesis and respiration is a prerequisite for any systematic understanding of ecology.

Perhaps because of its curricular importance, there are many studies that focus on photosynthesis and respiration in plants concepts (Amir & Tamir, 1994; Anderson, Sheldon & Dubay, 1990; Haslam & Treagust, 1987; Simpson & Arnold, 1982a; Tekkaya & Balcı, 2003; Tekkaya, Özkan & Aşçı, 2001; Waheed and Lucas (1992), Wandersee, 1985). Anderson et al. (1990) focused on college students' understanding of respiration and photosynthesis and administered a written test, including 13 questions. They found that the definitions offered by most students for the terms; respiration, photosynthesis and food, were different from the scientifically accepted ones. For the definition of the term respiration, none of the students mentioned glucose or any related compound, few of students mentioned food or energy. Rather than a scientific definition, students provide a

common-language definition of respiration, in which the term is used as a synonym for breathing. In their study, students defined respiration as;

- Exhaling CO_2 for humans, exhaling O_2 for plants.
- Breathing.
- Air in, air out.

Another term that students have misconceptions was photosynthesis. They gave definitions of photosynthesis such as;

- All I remember is it has to do with green plants and light.
- Plants take in CO_2 and change it to O_2.
- When the sun is directly on the plant- the plant will go through photosynthesis.
- Keeps plants green.
- Green plants turn sun and CO_2 into chlorophyll.

Few students mentioned glucose or food as a product of photosynthesis and conversion of sunlight to food energy in their definitions or photosynthesis. Like respiration, food is a term that is used in common-language. Most of the students defined food as substances; such as water, minerals, soil, sunlight, fertilizer, that plants take in from their environment. The results of this study also revealed that the students could not explain sources of energy for plants and animals, the nature of energy and chemical conversions in plants and animals. Similar findings were found by Simpson and Arnold (1982a). In their study they have interviewed with 113, 11-year old students to ascertain their understanding of these topics through life experiences and before receiving formal teaching. In addition to the findings revealed with the study of Anderson et al. (1990), Simpson and Arnold (1982a) reported that students have difficulty to relate food, digestion and energy. A high number of students stated that energy is obtained from food, digestion is the breakdown of food therefore digestion (not respiration) is the energy releasing process. Similarly, Amir and Tamir (1994) studied 11^{th} and 12^{th} grade students' misconceptions related with photosynthesis. They reported similar findings. Several examples of students' misconceptions about photosynthesis and

respiration in plants reported in the study were; photosynthesis is the respiration of plants, photosynthesis is the opposite of respiration, photosynthesis and respiration are complementary processes, the CO_2 released by respiration is used in photosynthesis, light energy is converted into chemical energy by photosynthesis and later released through respiration.

Another study that focused on students' misconceptions about photosynthesis and respiration in plants was conducted by Haslam and Treagust (1987). They developed a two-tier multiple choice instrument to diagnose secondary school students' misconceptions of photosynthesis and respiration in plants. The researchers administered this instrument to 438 students from grade levels 8-12. They found that students from different grade levels have similar misconceptions about photosynthesis and respiration in plants such as;

- Photosynthesis occurs in green plants all the time.
- Photosynthesis can occur when there is no light energy.
- Respiration in green plants takes place only during the day.
- Oxygen gas is used in respiration in which only occurs in green plants when there is no light energy to photosynthesize.
- Green plants respire only when there is no light energy.
- Respiration in plants takes place in the cells of the leaves since only leaves have special pores to exchange gases.
- Respiration in green plants is a chemical process to obtain energy which occurs in plant cells but not in animal cells.
- Green plants respire only at night (when there is no light energy).
- In the process of respiration carbon dioxide and water are used by the green plant to produce energy during which time glucose and oxygen waste are produced.

- The green pigment called chlorophyll combines with the carbon dioxide in the presence of light energy and produces glucose and water.
- Respiration takes place in all plants only when there is no light energy and in all animals all the time.

Tekkaya and Balcı (2003) conducted a cross-age study to investigate high school students' understanding of photosynthesis and respiration in plants. A total of 193 students from grade levels 9-11 were participated in the study. Students' misconceptions were identified by using photosynthesis concept test including open ended, true-false and multiple choice questions. In addition to the findings of Haslam and Treagust (1987), Tekkaya and Balcı (2003) reported several additional misconceptions about photosynthesis and respiration in plants such as;

- Photosynthesis is the respiration of green plants.
- Photosynthesis is the respiration of plants by using carbon dioxide.
- Plants convert carbon dioxide into oxygen by photosynthesis.
- Plants make respiration at night when there is no sunlight.
- Respiration is a transfer of gases.
- Plants do not make respiration.
- Photosynthesis is the respiration of plants during daylights.

Another cross-age study was conducted by Tekkaya, Özkan and Aşçı (2001). They have studied high school and university students' understanding of respiration. The sample of the study consisted of 191 students; 101 tenth grade and 90 university students. The researchers reported similar findings that Haslam and Treagust (1987) and Tekkaya and Balcı (2003) found in their research. The researchers of these three studies claimed that traditional instructional methods are not effective to rectify students' misconceptions and they suggest that

instructional methods that rectifies students' misconceptions and cause conceptual change should be used during instruction.

In addition to these studies mentioned above, it is worthwhile to state the findings of the studies conducted by Waheed and Lucas (1992). They searched for students' understanding of ecological, biochemical, physiological and energy change aspects of photosynthesis and their relationships in their study. The sample of the study consisted of 74 (14- 15 years old) students of fourth year science classes of three London secondary schools. They administered open ended questions and found that students have several misconceptions such as; "plants breath out carbon dioxide which animals inhale and this changes into oxygen into them and this process keeps going on". The researchers suggested that more attention should be given to teach relationships between interrelated concepts.

Another study that should be mentioned was conducted by Wandersee (1985). In his research, he highlighted many significant historical findings related to the concepts, plant nutrition, photosynthesis, and its role in energy flow through a community. As Wandersee also mentioned, perhaps the most famous experiment showing the plants make food, was conducted by Jan Baphista van Helmunt in 1648. It was one of the first carefully designed biological experiments reported. Van Helmunt, in his experiment, planted a willow tree in a pot and recorded the weight of the plant and the amount of soil. He watered the plant as needed. After five years he again measured the tree and the amount of soil. He observed that since the tree gained a lot of weight, the soil had lost very little. As a result of his experiment, Van Helmunt concluded that the willow tree had derived all its growth from the water, none from the soil or air. In 1772, Joseph Pristley after a series of experiments found that a burning candle within a closed container somehow "damaged" the air, making it no longer capable of supporting life. The candle burned only a short time and mice placed into such air soon suffocated. However, if a green plant was placed into a glass container of such "damaged"

air, the plant restored the air so that a mouse could live in it. This "restoring" factor is now known as oxygen. Wandersee (1985), in his research, concluded that the history of science can serve as a valuable adjunct for modern science teaching.

As given above most of the studies related with students' misconceptions about photosynthesis and respiration in plants recommended that traditional instruction is not effective to eliminate students' misconceptions.

2.2 Constructivism

As its name implies, constructivism emphasizes building or constructing the knowledge. Eggen and Kauchak (1994) defined constructivism as a view of learning that says learners use their experiences to actively construct understanding that makes sense to them, rather than acquiring understanding by having it presented in an already organized form. Constructivist approach states a number of points about teaching and learning:

- As research studies investigated students enter the classrooms with their preexisting knowledge, which sometimes often contradict with scientists. Students' preexisting knowledge that is inconsistent with the scientists have been called misconceptions. Misconceptions affect further learning negatively. (Wheatley, 1991).
- Misconceptions are pervasive, stable and resistant to change through instruction. For this reason, teachers should encourage students to express their preexisting conceptions (Amir & Tamir, 1994; Fisher, 1985).
- Knowledge is not a fixed object; it is constructed by the learner through experiences. Students should actively be involved in the learning process to construct their own knowledge.

- Since learning occurs through experience, if the information is presented with concrete, hands-on activities, students will learn more effectively.
- Since learning is a social process students should be allowed to express their ideas. Group works will help to enhance students' learning. In group works, students can present their ideas and through discussion with their peers, they can develop their conceptual understanding of various topics.

Constructivist classrooms differ from traditional classrooms in several ways. In a traditional classroom, students wait for the teacher to present the correct information. Practice, repetition, and reinforcement of correct answers allow actual learning to be accomplished. Teachers concentrate on how to teach and what to evaluate. They measure observable behavior rather than conceptual change or understanding. Students are passive receivers and memorize a variety of terms but often cannot apply them to problems or outside experiences, because they do not truly understand them. However, in a constructivist classroom, knowledge is not transferred from teacher to student. Students try to build their own explanations and actively participate in learning. Collaboration with peers and the teacher is very important because learning depends on the shared experiences. Vygotsky, recognized the importance of social interaction of a child with other child. He mentioned that, in communicating with other students, the student is able to dialogue and share ideas that help to facilitate their cognitive growth. Learning is a social process and occurs in a social context in which students are allowed to express their ideas about certain topics. As a result in a constructivist classroom cooperative learning is mostly used as a teaching method. According to constructivists the role of the teacher is to provide the necessary environment, guide the students through the learning process, and help them to identify their misconceptions. The teacher acts as a facilitator and assists the students when needed. Before the instruction, the teacher examines students' understanding and designs the instruction to eliminate these misconceptions. The focus is not on meeting the objectives and mastering tests because it is not enough to determine how much learning has occurred or track the process of

conceptual change. Constructivist teachers use additional resources besides the textbooks; such as, videotapes, computer programs and additional books.

2.3 Conceptual Change Approach

Students' views have a considerable influence on how and what they learn from their classroom experiences (Gilbert, Osborne & Fensham, 1982). For meaningful learning to occur students should be active during the learning process so, the instruction should be student-centered. In order to eliminate students' misconceptions and to provide meaningful learning in science, one of the most effective strategies is conceptual change approach. Conceptual change approach was originated from constructivist framework in general. Conceptual change is defined as restructuring or exchanging existing conceptions with the new concepts. Piaget stated that accommodation was necessary for conceptual change to occur, however he did not present a theory as to how this should be accomplished. Posner, Strike, Hewson and Gertzog (1982) investigated under what conditions accommodation occurs. According to Posner et al (1982) for accommodation to occur: (a) Students must be dissatisfied with their existing conceptions. Students' current concepts and ideas must be unsatisfactory to make sense of a phenomenon. (b) The new conception must be intelligible. Students must be able to grasp the alternative conception. (c) The new concept must appear plausible. Newly adopted concept must have the capacity to solve the problems. (d) The new concept must be fruitful. New concept should be extended and it should open up new areas of inquiry.

Presenting a new concept to the student and telling him that his views are inaccurate will not result in conceptual change. Instructional strategies should promote conceptual change. Many instructional strategies were developed and adapted to classrooms originating in the conceptual change theory and constructivism. These instructional strategies share a similar structure proposed by Nussbaum and Novick (1982):

Determining students' misconceptions

1. Discussing and evaluating those misconceptions
2. Creating conceptual conflict with those misconceptions
3. Encouraging and guiding conceptual restructuring.

2.4 Learning Cycle

Learning cycle is an alternative teaching strategy, developed by Karplus and Their, that first assesses students' misconceptions and then promotes conceptual change. Karplus Learning Cycle consists of three phases: exploration, concept introduction and concept application. In the exploration phase of the learning cycle, students discover new concepts with the guide of the teacher. The students confront with their previous experiences and existing knowledge in this phase. During concept introduction, students are introduced to a new concept. In this phase teachers can use a textbook, a film, a CD to introduce the concept. Students develop relationships between the concepts in this phase. In the concept application phase, students apply their new concept into new situations.

The 5E learning cycle based instruction was developed by the Biological Sciences Curriculum Study (BSCS) in 1989. It consists of 5 phases called as; Engagement, Exploration, Explanation, Elaboration and Evaluation.

* **Engagement:** In this phase activities that initiate students' curiosity are made. These activities help students to make connections with the previous knowledge. Asking questions and posing a problem may be included in the engagement activities.

What the teacher does consistent with this model:

- Creates interest.
- Generates curiosity.
- Raises questions.

- Elicits responses that uncover what the students know or think about the concept/ topic. (Carin & Bass, 2000, p.120-121)

What the student does consistent with this model:

- Asks questions such as: "Why did this happen?", "What do I already know about this?", "What can I find out about this?"
- Shows interest in the topic. (Carin & Bass, 2000, p.120-121)

*** Exploration:** Once students are engaged in the learning tasks, exploration activities follow. In exploration, students observe properties, form simple relationships, note patterns and raise questions about events to develop fundamental awareness of the nature of materials and ideas. They have the opportunity to get directly involved with phenomena. The teacher's role in the exploration phase is that of guide, coach and facilitator.

What the teacher does consistent with this model:

- Encourages students to work without direct instruction from the teacher.
- Observes and listens to students as they interact.
- Asks probing questions to redirect students' investigations when necessary.
- Provides time for students' investigations when necessary.
- Provides time for students to puzzle through problems.
- Acts as a consultant for students. (Carin & Bass, 2000, p.120-121)

What the student does consistent with this model:

- Thinks freely, but within the limits of the activity.
- Tests predictions and hypotheses.
- Forms new predictions and hypotheses.
- Tries alternatives and discusses them with others.
- Records observations and ideas.
- Suspends judgment. (Carin & Bass, 2000, p.120-121)

*** Explanation:** In this phase, teachers help students make sense of their observations and the questions that arise from their observations. The teacher asks children to describe what they see and give their own explanations of why it happened. Then, the teacher introduced a scientific explanation for the event through formal and direct instruction. The teacher connected the scientific explanation with the physical evidence from exploration and engagement and relates it to the explanations that the children have formed. Verbal methods are most common here, but the teacher might also use videos, books, multimedia presentations, and computer courseware.

What the teacher does consistent with this model:

- Encourages students to explain concepts and definitions in their own words.
- Asks for justification (evidence) and clarification from students.
- Formally provides definitions, explanations and new labels.
- Uses students' previous experience as the basis for explaining concepts. (Carin & Bass, 2000, p.120-121)

What the student does consistent with this model:

- Explains possible solutions or answers to the others.
- Listens critically to one another's explanations.
- Questions one another's explanations.
- Listens to and tries to comprehend explanations offered by the teacher.
- Refers to previous activities.
- Uses recorded observations in explanations. (Carin & Bass, 2000, p.120-121)

*** Elaboration:** In this phase new experiences are designed to assist children in developing broader understandings of the concepts already introduced. Students expand on the concepts they have learned, make connections to other related concepts, and apply their understanding to the real world around them. Children work in cooperative groups, identify and complete new activities. It often involves experimental inquiry, investigative projects, problem solving and decision making. Lab work is common. Small-group and whole-class discussions provide students opportunities to present their own understandings. By observing the students in this phase the teacher may decide to recycle through the different phases of the 5E learning cycle to improve children's understanding or move on to new science lessons.

What the teacher does consistent with this model:

- Expects students to use formal labels, definitions, and explanations provided previously.
- Encourages students to apply or extend the concepts and skills in new situations.
- Reminds students of alternative explanations.
- Refers students to existing data and evidence and asks: "What do you already know?" "Why do you think…?"

(Strategies from Explore apply here also.) (Carin & Bass, 2000, p.120-121)

What the student does consistent with this model:

- Applies new labels, definitions, explanations, and skills in new, but similar, situations.
- Uses previous information to ask questions, propose solutions, and make decisions, design experiments.
- Draw reasonable conclusions from evidence.
- Records reasonable conclusions from evidence.
- Records observations and explanations.
- Checks for understanding among peers. (Carin & Bass, 2000, p.120-121)

* **Evaluation:** Evaluation and assessment occurs at all points along the continuum of the instructional process. Rubrics, teacher observation structured by checklists, student interviews, portfolios designed with specific purposes, project and problem-based learning products, concept maps and roundhouse diagrams may be used to assess students' understanding of concepts. The roundhouse diagram is learning tool proposed by Wandersee in 1994. It is a two-dimensional geometric figure, which has a circular shape with seven sectors. The seven sectors are based on the study of George Miller (1956) who determined that most people can effectively recall seven items, plus or minus two. The roundhouse diagram allows the teacher to visualize a student's mental representation of what is already known (Trowbridge and Wandersee, 1998). By using this tool the teacher can detect students' misconceptions and correct the inaccurate conclusions. Roundhouse diagrams may be used as a tool in the evaluation part. By using these tools teachers observe students as they apply new concepts and skills to assess students' knowledge and/or skills, looking for evidence that the

students have changed their thinking or behaviors. The opportunity to allow students to assess their own learning and group-process skills is often provided.

What the teacher does consistent with this model:

- Observes students as they apply new concepts and skills.
- Assesses students' knowledge and/ or skills.
- Looks for evidence that students have changed their thinking or behaviors.
- Allows students to assess their own learning and group-process skills
- Asks open-ended questions, such as: "Why do you think….?", "What evidence do you have?", "What do you know about x?" How would you explain x?" (Carin & Bass, 2000, p.120-121)

What the student does consistent with this model:

- Answers open-ended questions by using observations, evidence, and previously accepted explanations.
- Demonstrates an understanding or knowledge of the concept or skill.
- Evaluates her own progress and knowledge.
- Asks related questions that would encourage future investigations. (Carin & Bass, 2000, p.120-121)

Several studies showed that 5E learning cycle is an effective teaching strategy and enhances students' understanding and achievement. Bevenino, Dengel and Adams (1999) explored that 5E learning cycle encourages students to develop their own frames of thought. Colburn and Clough (1997) also stated similar findings and stated that 5E learning cycle is an effective way to help students

enjoy science, understand content and apply scientific processes and concepts to authentic situations.

2.5 Conceptual Change Texts

Research shows that conceptual change text based instruction is one of the teaching strategies based on conceptual change theory (Alparslan, Tekkaya & Geban, 2003; Chambers & Andre, 1997; Mikkilä, 2001; Tekkaya, Sungur & Geban, 2001; Wang & Andre, 1991).

Wang and Andre (1991) studied the effects of conceptual change texts on students' understanding of electricity concepts. The sample of the study consisted of 139 college students. Students' preconceptions about electrical circuits are included in the conceptual change text. Traditional text about electrical circuits is used as a control in the study. The researchers reported that conceptual change text improved acquisition of electrical circuit concept. Similar to the results that Wang and Andre found in their research, Chambers and Andre (1997) studied the effect of conceptual change text on students' understanding of direct current concepts. According to the results of their study they have found that conceptual change text was effective in learning about electricity concepts for both male and female students.

Mikkilä (2001) investigated the effect of conceptual change text on 5^{th} grade students' understanding of photosynthesis concept. The sample of the study consisted of 209 students. Control group in the study was treated with traditional text and the experimental group treated with conceptual change text. The results of this study investigated that conceptual change text is effective on students' understanding of photosynthesis concept.

Tekkaya, Sungur and Geban (2001) conducted a study to investigate the contribution of conceptual change texts accompanied by concept mapping instruction to 10^{th} grade students' understanding of human circulatory system.

The sample of the study consists of 49 tenth-grade students. The researchers developed a 16 item multiple choice test to determine students' understanding of the human circulatory system. The control group in the study was instructed with traditional instruction and the experimental group was instructed with conceptual change text approach accompanied with concept mapping. The results of the study showed that the students in the experimental group which received conceptual change text approach accompanied with concept mapping have better understanding of the concepts related with human circulatory system.

Another study that focused on the effects of conceptual change texts on students' understanding was made by Alparslan, Tekkaya and Geban (2003). They conducted a study to investigate the effect of conceptual change instruction on 11^{th} grade students' understanding of respiration. The sample of the study consisted of 68 students. The control group was instructed with traditional instruction in which teacher used lecture and discussion methods. The experimental group was instructed with conceptual change texts. The results of the study showed that the conceptual change instruction is effective on students' understanding of respiration.

In the light of the related literature, it can be said that students' have several misconceptions about photosynthesis and respiration in plants and these misconceptions influence their further learning negative way. Therefore instructional strategies that will eliminate students' misconceptions should be applied in classroom situations. For this reason this study is focused on students' misconceptions about photosynthesis and respiration in plants and instructional strategies (5E learning cycle based instruction and conceptual change text based instruction) that improve students' understanding of photosynthesis and respiration in plants.

CHAPTER 3

PROBLEMS AND HYPOTHESES

This chapter includes the main problem, related sub-problems and the hypotheses of the study.

3.1 Main Problem

The main problem of the study is:

What are the effects of different instructions; 5E learning cycle based instruction, conceptual change text based instruction, and traditional instruction, on 8th grade students' understanding of photosynthesis and respiration in plants and attitudes toward science as a school subject?

3.2. Sub-problems

Based on the main problem of the study the following sub-problems are stated:

1. Are there significant differences among the effects of 5E learning cycle based instruction (5E-LCBI), conceptual change text based instruction (CCTBI) and traditional instruction (TI) on students' understanding of photosynthesis and respiration in plants, when photosynthesis and respiration in plants concepts pre-test scores (PRE-TEST scores) and test of logical thinking scores (TOLT scores) are controlled as covariates?

Is there a significant difference between the effects of 5E-LCBI and TI on students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates?

Is there a significant difference between the effects of CCTBI and TI on students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates?

Is there a significant difference between the effects of 5E-LCBI and CCTBI on students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates?

2. Is there a significant difference between boys and girls with respect to their understanding of photosynthesis and respiration in plants, when their PRE-TEST scores and TOLT scores are controlled as covariates?

3. Is there a significant effect of interaction between gender difference and treatment with respect to students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates?

4. What is the contribution of students' reasoning abilities to their understanding of photosynthesis and respiration in plants?

5. Are there significant differences among the effects of different instructions; i.e. 5E-LCBI, CCTBI and TI, on students' attitudes toward science as a school subject, when science attitude pre-test scores (PRE-ATT scores) and TOLT scores are controlled as covariates?

5.1 Is there a significant difference between the effects of 5E-LCBI and TI on students' attitudes toward science as a school

subject, when PRE-ATT scores and TOLT scores are controlled as covariates?

5.2 Is there a significant difference between the effects of CCTBI and TI on students' attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates?

5.3 Is there a significant difference between the effects of 5E-LCBI and CCTBI on students' attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates?

6. Is there a significant difference between boys and girls with respect to their attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates?

7. Is there a significant effect of interaction between gender difference and treatment with respect to their attitude toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates?

3.3 Hypotheses:

The sub-problems stated above are tested statistically by the following hypotheses:

$H_0$1: There are no significant differences among post-test mean scores of the students taught with 5E-LCBI, CCTBI and TI in terms of understanding photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates.

$H_0$2: There is no significant difference between the post-test mean scores of boys and girls in terms of understanding photosynthesis and respiration in plants, when their PRE-TEST scores and TOLT scores are controlled as covariates.

$H_0$3: There is no significant effect of interaction between gender difference and treatment on students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates.

$H_0$4: There is no significant contribution of students' reasoning abilities to understanding of photosynthesis and respiration in plants.

$H_0$5: There is no significant mean difference among post-test mean scores of students taught with 5E-LCBI, CCTBI and TI with respect to their attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates.

$H_0$6: There is no significant difference between post-test mean scores of boys and girls with respect to their attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates.

$H_0$7: There is no significant effect of interaction between gender difference and treatment with respect to their attitudes toward science as a school subject, when PRE-ATT and TOLT scores are controlled as covariates.

CHAPTER 4

METHOD

This chapter includes overall research design, information about the subjects of the study, variables of the study, data collection procedures, treatment and data analysis procedure.

4.1 Research Design

This study utilized the quasi experimental design (Gay, 1987), since it was not possible to assign the students to classes randomly. The research design of the study is outlined in Table 4.1.

Table 4.1 Research Design of the Study

Groups	Pretest	Treatment	Posttest
EG 1	TOLT, PRPCT, ASTS	5E-LCBI	PRPCT, ASTS
EG 2	TOLT, PRPCT, ASTS	CCTBI	PRPCT, ASTS
CG	TOLT, PRCPT, ASTS	TI	PRPCT, ASTS

In this table, EG1 represents the Experimental Group 1 instructed by 5E learning cycle; EG2 represents Experimental Group 2 instructed by conceptual change texts. CG represents Control Group received traditional instruction. TOLT is Test of Logic Thinking, PRPCT is Photosynthesis and Respiration in Plants Concept Test, ASTS is Attitude Scale Toward Science. 5E-LCBI refers to 5E-

Learning Cycle Based Instruction, CCTBI refers to Conceptual Change Text Based Instruction and TI refers to Traditional Instruction.

4.2 Subjects of the study

The subjects of the study consisted of 101 eigth grade students from three intact classes from one of the elementary schools in Ankara. This study was carried out during the fall semester of 2003-2004 academic year. Three classes were instructed by the same science teacher. The instructional methods were randomly assigned to the groups. This study utilized two experimental groups and one control group. The first experimental group consisted of 33 students and treated with 5E learning cycle based instruction. The second experimental group consisted of 34 students and treated with conceptual change text based instruction. The control group consisted of 34 students and instructed with traditional instruction. The distribution of the subjects is given in Table 4.2

Table 4.2. Distribution of Subjects of the Study.

Group / Gender	Experimental Groups		Control Group	Total
	5E-LCBI	**CCTBI**	**TI**	
Girls	15	12	17	44
Boys	18	22	17	57
Total	33	34	34	101

4.3 Variables

In the present study variables are categorized as dependent, independent and covariates.

4.3.1 Dependent Variables

Students' understanding of photosynthesis and respiration in plants measured by PRPCT and students' attitudes toward science as a school subject measured by ASTS are the dependent variables of the study.

4.3.2 Independent Variables

The instructional methods; 5E learning cycle based instruction, conceptual change text based instruction and traditional instruction, and gender are the independent variables of the study.

4.3.3 Covariates

Pre-test scores of concept test, scores of test of logic thinking and pre-test scores of attitude test are the covariates of the study.

4.4 Data Collection Instruments

The instruments used to collect data were; "Photosynthesis and Respiration in Plants Concept Test", "Attitudes Toward Science as a School Subject" and "Test of Logical Thinking".

4.4.1 Photosynthesis and Respiration in Plants Concept Test

This test, originally called "What do You Know About Photosynthesis and Respiration in Plants?", was developed by Haslam and Treagust (1987). It was administered to determine students' understanding of photosynthesis and respiration in plants. It included 13 two-tier multiple-choice questions. The first tier of each item consisted of content knowledge with two, three of four alternatives and the second tier consisted of reasons for the first tier, including a scientifically correct answer and three identified misconceptions (Haslam & Treagust, 1987). A student's answer to an item was considered correct if the student answered both the content part and the reason part correctly. Since the language of the instruction was Turkish in the school, the test was translated to Turkish by the researcher (see Appendix B). The translated version of the test was examined by an expert, who knows the linguistic of two languages. Each item in the test was examined by a group of science educators regarding content validity and format. The classroom teacher also examined the test items to check whether they are appropriate to the instructional objectives or not. The reliability

of the test was found to be 0.70. The test was administered to both experimental and control groups as pre-test and post-test.

4.4.2 Attitude Scale Toward Science

This scale, developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (1994), was used to measure students' attitudes toward science as a school subject. It consists of 15 items in 5-point likert type scale (strongly agree, agree, undecided, disagree, strongly disagree). The reliability of the scale was found to be 0.83. This test was administered to students in all groups before and after the treatment (See Appendix C).

4.4.3 Test of Logic Thinking

This test was originally developed by Tobin and Capie (1981) to determine students' reasoning abilities. It was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). It consisted of 10 items related to identifying and controlling variable and proportional, correlational, probabilistic and combinatonial reasoning (See Appendix A). The reliability of the test was found to be 0.81.

4.5 Treatment

This study was conducted over a period of three weeks during the 2003-2004 fall semester. Three classes including 101 students were involved in the study. These three classes were instructed by the same science teacher. The instructional methods were randomly assigned to the classes. Instructions in all the classes were observed by the researcher to verify the treatment. Students in all groups were exposed to same content for the same duration. The duration of the lessons was three 40-minutes periods per week. The topic related to photosynthesis and respiration concepts was covered as a part of the regular curriculum. At the beginning of the study TOLT, PRPCT and ASTS were administered all the groups to determine their reasoning abilities, their understanding of

photosynthesis and respiration in plants and their attitudes towards science respectively.

Students in the control group received traditional instruction. At the beginning of the instruction, they read the topic from their textbooks in the classroom. Then, the teacher explained the concepts related with photosynthesis and respiration in plants; concept of producer, food of plants, photosynthesis, the purpose of photosynthesis, what plants need for photosynthesis, what plants produce as a result of the photosynthesis, respiration, how and when respiration occurs in plants, by using lecture and discussion methods. After explaining the concepts, the teacher conducted four experiments related with photosynthesis given in the textbook. The students did not actively participated in experiments, they only observed their teacher while she is conducting the experiments. The teacher demonstrated the experiments and she followed the procedure given in the textbook while conducting the experiments. After the experiments the teacher asked several questions related with the results of the experiments, take the student responses and explained the results.

Students in the first experimental group were instructed with 5E learning cycle based instruction. At the beginning of the treatment, students' misconceptions were determined by PRPCT, then two separate 5E learning cycle based lessons, one for the photosynthesis (See Appendix D) and one for the respiration in plants (See Appendix E), were designed by focusing on students' misconceptions and lesson objectives. The designed 5E lessons were examined by experts in science education. Before beginning the instruction the teacher was informed about 5E learning cycle in three one hour training sessions. At the beginning of the instruction the teacher divided the classroom into groups to maximize student-student interaction.

Engagement:

The instruction began with the "Engagement" part. As a first step, the teacher asked several questions to activate the prior knowledge of students and stimulate their thinking such as; "What is food of plants?", "What is food of animals?". The teacher requested students to discuss the questions with their friends and write the answers to their notebooks. During the discussion, the teacher didn't interfere with the students. After discussion, the teacher asked the answer of the question to the students and each group give an answer reflecting their thinking to the teacher. In this way, the teacher had opportunity to view students' previous ideas. The answers of this question showed that most of the students have misconceptions related to food of plants. Students stated that water, inorganic salts, carbon dioxide, fertilizers and sunlight are food of plants.

Exploration:

In the exploration part the students were given an experimental situation, in which a green plant weighing 500 g. without any soil on its roots, was planted in a tub of soil. The experimenter only watered the plant but did nothing else. After the plant had grown 5 years, the experimenter removed the plant and weighed it again. The weight of the plant was 4 kg. It was asked to students that what happened to the weight of the soil in the tub after the plant grew in it 5 years and gained so much weight. Three situations related with the weight of the soil were given to students, the soil has lost a lot of weight, the soil's weight stayed about the same, the soil gained a lot of weight. The students have discussed with their classmates and noted their answers to their notebooks. When the teacher asked the answers of the students, most of the students said that the soil has lost a lot of weight by thinking the soil as the source of plants' weight. Both in the engagement part and exploration part, the teacher had an opportunity to observe students' misconceptions.

Explanation:

In the explanation part, the teacher introduced the concept of producer, food of plants, photosynthesis, the purpose of photosynthesis, what plants need for photosynthesis, what plants produce as a result of the photosynthesis. In the explanation part the teacher emphasized misconceptions of students and explained why they are wrong.

Elaboration:

In the elaboration part, the students discussed how they can design experiments to test what plants need for photosynthesis and what they produce as a result of photosynthesis. Then, they conducted the experiments. Students also discussed whether there are other factors that affect the photosynthesis (enzymes, temperature etc.) in this phase.

Evaluation:

Assessment occured at all points along the instruction. During the lesson the teacher asked questions to students, observed them through discussions and hands-on activities and decided whether they gained the necessary concepts or not. In addition to this, several questions including open-ended, multiple choice questions are asked to students at the end of the instruction. The teacher distributed the questions to the students and gave time to think about the answers of the questions. Then the answers of the questions are discussed in the classroom.

After the photosynthesis topic, the teacher started to the topic respiration in plants.

Engagement:

The teacher started to the instruction with the following questions; “How do living things obtain energy required to continue their lives?”. This question was asked to students to activate their prior knowledge and stimulate their thinking.

The students discussed the answer of the question with their peers and noted their answers to their notebooks. The teacher asked that what they think about the answer of the question and each group gave an answer reflecting their thinking. Several sample answers of students are as follows: “Animals respire and plants photosynthesize to get the energy they need”, “plants do not make respiration because they do not need energy”, “animals respire all the time but plants respire only in daylight because plants need energy only when they photosynthesize”. After discussing the question the students started with the exploration part.

Exploration:

In the exploration part an experimental situation was given; in which a student puts a plant and lime water together closed with a fanus and it was asked what he is going to test. Another question related with the situation was about what is going to be happen to the lime water in dark places and light places. This situation was given to students to explore that plants breath all the times and photosynthesise in light places. In the exploration part, like in the engagement part, students worked cooperatively with their friends, discussed and shared their ideas. The teacher acted as a facilitator and helped students to discuss the concepts.

Explanation:

In the explanation part the teacher explained the concept respiration, how and when respiration occurs in plants. The teacher encouraged students to explain concepts and definitions in their own. During the explanation part the teacher emphasized on students’ misconceptions and explained why they were wrong.

Elaboration:

In the elaboration phase the following situation is explained to the students; Animals use food to get the energy they need. They use oxygen and produce carbon dioxide, all the time. Plants also use food to get the energy they need. They also use oxygen and carbon dioxide, all the time. But during the day, green

plants build up food! To do this, they use up carbon dioxide, and produce oxygen. Overall, green plants produce more oxygen than they use. In this way, oxygen and carbon dioxide are constantly being taken from and added to the atmosphere. Up till about 200 years ago, the amounts of oxygen and carbon dioxide in the atmosphere stayed roughly the same. The green plants produced all the oxygen which the animals need. But since then, the amounts of oxygen and carbon dioxide in the atmosphere changing. What may be the reasons of this change?" The teacher requested students to discuss their ideas with their friends and observed the students if they were able to use the concepts in correct situations.

Evaluation:

The continuous evaluation and assessment was made during the instruction. Several questions; multiple choice questions and open ended questions were asked to students at the end of the instruction to see whether they have gained the concepts correctly or not. The teacher distributed the questions to the students, gave they time to think about the answers of questions. Then the answers of the questions were discussed in the classroom. The teacher requested students to fill a roundhouse diagramme at the end of the instruction as a homework. Next day, students brought the roundhouse diagrammes they have filled in (see Appendix H), the teacher examined the diagrams and looked for if there still exist misconceptions related with the topic.

In the second experimental group the students were instructed with conceptual change text based instruction. Two conceptual change texts, one for photosynthesis and one for respiration in plants, were prepared by the researcher (See Appendix F and G). These conceptual change texts were constructed by using conditions proposed by Posner et al. (1982): intelligibility, plausibility, fruitfulness and dissatisfaction. The classroom teacher examined the texts if the content is suitable for the grade level. Before beginning the conceptual change text based instruction the teacher was informed how to use the conceptual change texts in two one hour training sessions. The conceptual change texts were given

to students to be read 3 or 4 days before the class hour. Students were asked to read the texts before the class hour and bring them to the class. The topic of photosynthesis and respiration in plants was divided into sub-topics such as food of plants, photosynthesis and respiration, respiration in green plants, where the respiration in plants occurs and when the respiration in plants occurs. For each sub-topic, a suggestive question was asked to students to arouse interest on the subject and to analyze students' preconceptions about the subject. Students discussed these questions by their classmates. It was expected that students were dissatisfied with their existing conceptions. The texts stated common misconceptions about photosynthesis and respiration in plants and did not directly inform the students about the subject. Students were wanted to compare their conceptions with these misconceptions. By this way conceptual conflicts were tried to be created. A scientific explanation was given to guide the students why the conception could be wrong. When needed blocks of information were given directly to help students to restructure the concepts. Nussbaum and Novick's (1982) steps (determining misconceptions, discussing and evaluation, creating conceptual conflict, and guiding restructuring) were followed throughout the texts. Some images are used when appropriate to help visualization. For example, substances needed for photosynthesis is demonstrated by using a plant figure and the sources of substances. Teacher-student and student-student interaction tried to be maximized by discussions. Experiments related with photosynthesis were carried out at the end of the topic. Students discussed how to design the experimental setup and conducted the experiment.

At the end of the treatment, all students were given PRPCT and ASTS as posttest to observe the effect of treatment.

4.6 Analysis of Data

In this study, Analysis of Covariance (ANCOVA) was used to analyze the data collected from the instruments described above.

4.7 Assumptions and Limitations

During this study, assumptions and limitations encountered are given as below:

4.7.1 Assumptions

1. The teacher who applied this study was not biased during the treatment.
2. There was no interaction between the students in the experimental and control groups.
3. All students' responses to the test items were sincere.

4.7.2 Limitations

1. The subjects in the treatment were limited to 101 eigth grade students from one of the secondary schools in Ankara.
2. The study was limited to the concepts "Photosynthesis and Respiration in Plants".
3. The study was limited to public schools.

CHAPTER 5

RESULTS AND CONCLUSIONS

This chapter presents the results of analysis of hypotheses stated in Chapter 3.

5.1 Results

The hypotheses were tested at a significance level of α=0.05. Analysis of covariance (ANCOVA) was used to test the hypotheses. SPSS/PC (Statistical Package for Social Science for Personal Computers) (Norusis, 1991) was used to carry out the statistical analyses in this study.

Students' Misconceptions Determined by Photosynthesis and Respiration in Plants Concept Test

Percentages of students in all groups who gave the correct answer to the items of Photosynthesis and Respiration in Plants Concept Test were given in Table 5.1. Statistical analyses revealed that before the instruction 20.75% of students, after the instruction 45.45% of students in the 5E-LCBI group gave correct answers, the gain is 24.7%. Statistics also showed that before the instruction 33.02 % of students and after the instruction 48.91% of students in the CCTBI group gave correct answers to the questions; the gain is 15.89%. For the traditional instruction, the statistics revealed that 38.89% of students before the instruction and 43.42% of students after the instruction gave correct answers to the questions; the gain is 4.53% for the traditional instruction.

Table 5.1. Percentages of students who answered the PRPCT questions correctly

Correct Items	% of students who answered the questions correctly					
	5ELCBI		CCTBI		TI	
	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST
1- Oxygen gas is given out in largest amounts by green plants in the presence of sunlight, because there is more of this gas produced by the green plant during photosynthesis than is required by the green plant for respiration and other processes, so the excess gas is given off.	3	15.2	11.8	14.7	29.4	11.8
2- Oxygen gas is taken in by green plants in large amounts when there is no light energy at all, because this gas is used in respiration which takes place continuously in green plants.	9.1	51.5	14.7	50.6	23.5	47.1
3- Carbon dioxide gas is given off by green plants in large amounts when there is no light enegy at all, because green plants stop photosynthesising when there is no light energy at all so they continue to respire and therefore they give off this gas.	45.5	72.7	58.8	70.6	67.6	52.9
4- Carbon dioxide gas is taken in by green plants in largest amounts in the presence of light energy, because green plants make their food from this gas in the presence of light energy.	45.5	69.7	47.1	61.8	52.9	58.8
5- Respiration in plants takes place in, because all living cells need energy to live.	15.2	12.1	20.6	47.1	23.5	8.8
6- Respiration is a chemical process which occurs in all living cells of plants and animals, because all living cells of plants and animals obtain energy to live through this process.	66.7	87.9	73.5	79.4	79.4	76.5
7- Respiration is a chemical process in which energy stored in food is released using oxygen, because respiration provides the green plant with energy to live.	12.1	24.2	20.6	44.1	23.5	41.2
8- Green plants respire all the time (whether there is light energy or when there is no light energy) because green plants need energy to live and respiration provides energy.	21.2	63.6	17.6	55.9	38.2	64.7
9- " glucose + oxygen $\longrightarrow$ energy + carbon dioxide + water " represents the process of respiration in plants, because green plants derive energy from glucose using oxygen.	3.0	24.2	23.5	38.2	23.5	20.6
10-" carbon dioxide + water $\xrightarrow[\text{chlorophyll}]{\text{light energy}}$ glucose + oxygen " represents the overall process of photosynthesis, because the energy from sunlight is used by green plants containing chlorophyll to combine carbon dioxide and water to form glucose and oxygen.	36.4	48.5	58.8	44.1	67.6	52.9
11- Amount of oxygen is not important for the process of photosynthesis, because oxygen is not required for photosynthesis, it is a biproduct of photosynthesis.	30.3	51.5	50.0	58.8	47.1	67.6
12- The most important benefit to green plants when they photosynthesis is conversion of light energy to chemical energy, because during photosynthesis energy from the Sun is converted and stored in glucose molecules.	9.1	18.2	8.8	23.5	5.9	8.8
13- Photosynthesis takes place in green plants in the presence of light energy and respiration takes place in all plants and in all animals at all times, because respiration is continuously occur in all living things. Photosynthesis occurs only when light energy is available.	18.2	51.5	23.5	47.1	23.5	52.9

Students' misconceptions identified by Photosynthesis and Respiration in Plants are given in Table 5.2.

Table 5.2. Students' misconceptions identified by Photosynthesis and Respiration in Plants Concept Test

Item	Misconceptions identified
1	Green plants give out carbon dioxide gas in large amounts in the presence of sunlight, because green plants only respire during the day.
1	Green plants give out oxygen gas in large amounts in the presence of sunlight, because they only photosynthesize and do not respire in the presence of light energy.
1	Green plants give out oxygen gas in large amounts in the presence of sunlight, because this gas is a waste product given off by green plants after they photosynthesize.
2	Carbon dioxide is taken in by green plants in large amounts when there is no light energy at al, because this gas is used in photosynthesis which occurs in green plants all the time.
2	Carbon dioxide is taken in by green plants in large amounts when there is no light energy at al, because this gas is used in photosynthesis which occurs in green plants all the time.
2	Oxygen is taken in by green plants in large amounts when there is no light energy at all, because this gas is used in photosynthesis which occurs in green plants when there is no light energy at all.
3	Since green plants respire only when there is no light energy they give off carbon dioxide.
3	Oxygen gas is given off by green plants during photosynthesis which takes place when there is no light energy.

Table5.2 continued.

4	Green plants make their food from oxygen gas in the presence of light energy.
5	Respiration in plants takes place in the cells of the roots only, because only roots have small pores to breathe.
5	Respiration in plants takes place in the cells of the leaves only, because only leaves have special pores (stomata) to exchange gas.
5	Respiration in plants takes place in the cells of the roots only, because only roots need energy to absorb water.
6	Respiration is a chemical process which occurs in plant cells but not in animal cells, because only plant cells obtain energy to live in this way.
6	Respiration is a chemical process which occurs only in animal cells but not in plant cells, because only animal cells need energy to live as they cannot photosynthesize.
6	Respiration is a process that does not take place in green plants when photosynthesis is taking place, because it only occurs when there is no light energy
7	Respiration is the exchange of carbon dioxide and oxygen gases through plant stomata, because green plants take in carbon dioxide and give off oxygen when they respire.
7	Respiration is a chemical process by which green plants manufacture food from water and carbon dioxide, because green plants never respire they only photosynthesize.
8	Green plants respire only at night (when there is no light energy), because cells of green plants can photosynthesize during the day when there is light energy and therefore they respire only at night when there is no light energy.

Table5.2 continued.

8	Green plants respire only during daylight, because green plants do not respire they only photosynthesize, and photosynthesis provides energy for the plant.
9	During respiration green plants take in carbon dioxide and water in the presence of light energy to form glucose.
9	Carbon dioxide and water are used by the green plant to produce energy during which time glucose and oxygen waste are produced.
9	During respiration, green plants derive energy from glucose using oxygen.
10	Glucose and oxygen is combined in the presence of chlorophyll and light energy to form carbon dioxide and water.
11	Amount of chlorophyll is not important for the process of photosynthesis, because non green plants like fungi which do not contain chlorophyll or similar pigments can also photosynthesize.
11	Amount of light is not important for the process of photosynthesis, because photosynthesis can take place with no light energy.
12	The most important benefit to green plants when they photosynthesize is removal of carbon dioxide from the air, because carbon dioxide is taken in by the leaf through the stomata during photosynthesis.
12	The most important benefit to green plants when they photosynthesize is the production of energy, because photosynthesis provides energy for plant growth.
13	Photosynthesis takes place in green plants only and respiration takes place in animals only, because green plants photosynthesize and do not respire at all.
13	Respiration takes place in all plants only when there is no light energy because plants respire when they cannot obtain enough energy from photosynthesis. Respiration takes place all the time in all animals, because they cannot photosynthesize.

5.2 Statistical Analysis of Hypotheses

At the beginning of the treatment there was a significant difference among the groups with respect to students' understanding of photosynthesis and respiration in plants concepts ($F(2,100)=3.398$; $p<0.05$). However, no significant difference was found among the groups with respect to their reasoning abilities ($F(2,100)=2.195$; $p>0.05$) and their attitudes toward science as a school subject ($F(2,98)=1.154$; $p>0.05$). There were two dependent variables; photosynthesis and respiration in plants concepts post-test scores and science attitude post-test scores in this study. In order to statistically equalize the differences among the experimental and control groups , three variables of the study; photosynthesis and respiration in plants concepts pre-test scores, test of logical thinking scores and science attitude pre-test cores were determined as covariates.

Hypotheses 1:

To test hypothesis 1 stating that there are no significant differences among post-test mean scores of the students taught with 5E-LCBI, CCTBI and TI in terms of understanding photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates, ANCOVA was used. The measures obtained are presented in Table 5.3.

Table 5.3. ANCOVA Summary (Understanding)

Source	SS	df	MS	F	P
Pre-test	51.798	1	51.798	9.080	0.003
TOLT	66.999	1	66.999	11.745	0.001
Treatment	49.272	2	24.636	4.319	0.016
Gender	7.517	1	7.517	1.318	0.254
Treatment*Gender	1.575	2	0.788	0.138	0.871
Error	530.530	93	5.705		

* $p<0.05$

The results showed that there were significant differences among the post-test mean scores of students taught by 5E-LCBI, CCTBI and those taught by TI with respect to the understanding of photosynthesis and respiration in plants ($F(2,93)=4.319$; $p<0.05$).

Post-hoc test was made for multiple comparisons of groups. According to the post-hoc test results, there was a significant difference between the post-test mean scores of students taught by 5E-LCBI and TI with respect to the understanding of photosynthesis and respiration in plants. Students taught by 5E-LCBI scored significantly higher than students taught by TI ($p<0.05$). The results also showed that there was a significant difference between the post-test mean scores of students taught by CCTBI and those taught by TI with respect to understanding of photosynthesis and respiration in plants. Students taught by CCTBI scored significantly higher than students taught by TI ($p<0.05$). However there was no significant difference between the posttest mean scores of students taught by 5E-LCBI and CCTBI with respect to understanding of photosynthesis and respiration in plants ($p>0.05$).

The proportions of correct responses distributed to questions in the posttest for all groups are shown in Figure 5.1. As it can be seen in the figure, there were differences of responses to the items among three groups. The proportions of correct responses of 5ELCBI and CCTBI are very close to each other. However, there are significant changes between the proportions of correct responses of experimental groups; 5E-LCBI and CCTBI, and control group; TI.

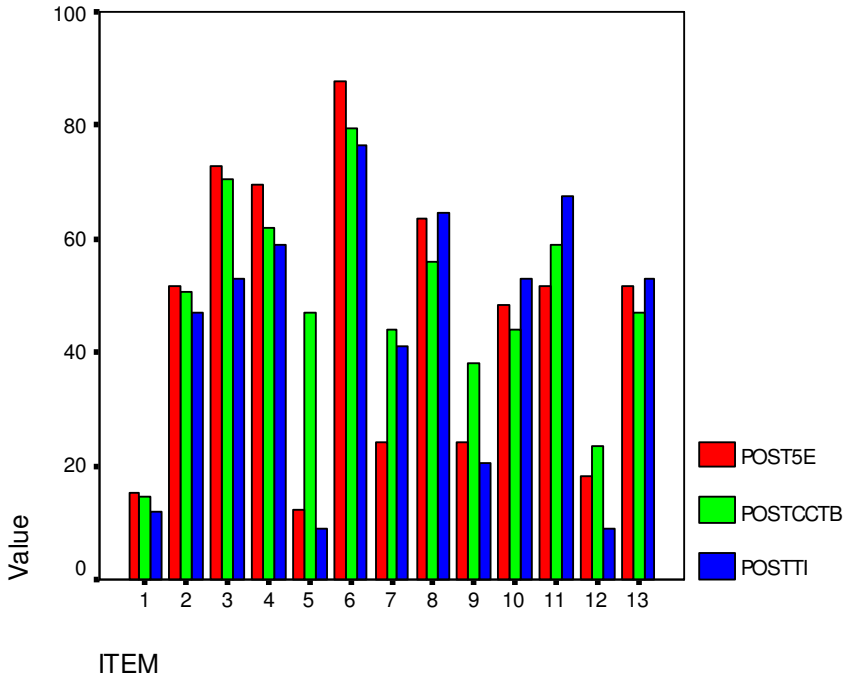

Figure 5.1 Comparison of 5E-LCBI, CCTBI and TI group with respect to correct responses to the items in the posttest.

Questions 1, 5, 7, 9 and 12 were the most significant ones of the poorly scored items. In question 1 students were asked that which gas is given out in largest amounts by green plants in the presence of sunlight and then give the reason. The proportions of correct responses of 5E-LCBI, CCTBI and TI for question 1 were 15.2%, 14.7% and 11.80% respectively. Most of the students responded in the favor of oxygen gas as it is given out in largest amounts by green plants in the presence of sunlight however they stated their reason as oxygen gas is a waste product given off by green plants after they photosynthesize.

In question 5 the students were asked about where the respiration in plants takes place in. The proportions of correct responses of 5E-LCBI, CCTBI and TI groups for question 5 were 12.1%, 47.1% and 8.8% respectively. Students were expected to explain the respiration takes place in all plant cells because all plant cells need

energy to live. However most of the students gave an answer to this question such as respiration in plants takes place in the cells of the leaves only, because only leaves have special pores (stomata) to exchange gas. The percentage of students that gave this answer is drastic. The percentage of students that gave this distracter as the answer of this question is 66% for 5E-LCBI, 14% for CCTBI and 70% for TI.

In question 7 students were asked to choose the most accurate statement about respiration in green plants and then give the reason. The proportions of correct responses of 5E-LCBI, CCTBI and TI were 24.2%, 44.1% and 41.2% respectively. Students were expected to explain respiration is a chemical process in which energy stored in food is released using oxygen because respiration provides the green plant with energy to live. However, most of the students stated that respiration in green plants is a chemical process by which plants manifacture food from water and carbon dioxide because green plants never respire they only photosynthesize.

In question 9 students were asked to choose the best equation that represents the process of respiration in plants and then give the reason. The proportions of correct responses of 5E-LCBI, CCTBI and TI for question 1 were 24.20%, 38.20% and 20.6% respectively. Students were expected to state that during respiration, green plants derive energy from glucose using oxygen. However, most of the students responded that carbon dioxide and water are used by the green plant to produce energy during which time glucose and oxygen waster are produced.

Another similar situation in the proportions of correct responses of 5ELCBI, CCTBI and TI groups for question 12 were 18.2%, 23.5%, and 8.8% respectively. In this question the most important benefit of photosynthesis to green plants is asked to students. Students were expected to state that the most

important benefit to green plants when they photosynthesize is conversion of light energy to chemical energy, because during photosynthesis energy from the Sun is converted and stored in glucose molecules. However most of the students gave an answer such as the most important benefit to green plants when they photosynthesize is production of energy because photosynthesis provides energy for plant growth.

Hypothesis 2:

To answer the question posed by hypothesis 2 which states that there is no significant difference between the post-test mean scores of boys and girls in terms of understanding photosynthesis and respiration in plants, when their PRE-TEST scores and TOLT scores are controlled as covariates, ANCOVA was run. Table 5.3 showed that there was no significant mean difference between boys and girls in terms of understanding photosynthesis and respiration in plants ($F(1,93)=1.318$; $p>0.05$).

Hypothesis 3:

To analyze hypothesis 3 which states that there is no significant effect of interaction between gender difference and treatment on students' understanding of photosynthesis and respiration in plants, when PRE-TEST scores and TOLT scores are controlled as covariates, ANCOVA was used. Findings in Table 5.3 revealed that interaction between gender difference and treatment was not significant ($F(2,93)=0.138$; $p>0.05$).

Hypothesis 4:

To test hypothesis 4, which claims that there is no significant contribution of students' reasoning abilities to understanding of photosynthesis and respiration in plants, ANCOVA was used. Table 5.3 represents the contribution of reasoning abilities to the understanding of photosynthesis and respiration in plants. The results indicated that there was a significant contribution of reasoning abilities on

student's understanding of photosynthesis and respiration in plants ($F(1,93)=11.745$; $p<0.05$).

Hypothesis 5:

To answer the question posed by hypothesis 5 which states that there is no significant mean difference among post-test mean scores of students taught with 5E-LCBI, CCTBI and TI with respect to their attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates, ANCOVA was used. Table 5.4 summarizes the result of this analysis.

Table 5.4 ANCOVA Summary (Attitude)

Source	SS	df	MS	F	P
AttPre	2043.407	1	2043.407	50.991	0.000
TOLT	9.12E-05	1	9.12E-05	0.000	0.999
Treatment	166.876	2	83.438	2.082	0.131
Gender	62.952	1	62952	1.571	0.213
Treatment*Gender	22.808	2	11.404	0.285	0.753
Error	3486.394	87	40.073		

The results showed that there was no significant difference among post-test mean scores of students taught with 5ELCBI, CCTBI and TI with respect to their attitudes toward science as a school subject, when PRE-ATT. scores and TOLT scores are controlled as covariates ($F(2, 87)=2.082$; $p>0.05$).

Hypothesis 6:

To analyze hypothesis 6, which states that there is no significant difference between post-test mean scores of boys and girls with respect to their attitudes toward science as a school subject, when PRE-ATT scores and TOLT scores are controlled as covariates, ANCOVA was used. Table 5.4 shows the effect of gender difference on students' attitudes. The findings revealed that there was no significant difference between post-test mean scores of boys and girls with respect to attitudes toward science as a school subject ($F(1,87)=1.571$; $p>0.05$).

Hypothesis 7:

To test the hypothesis, which claims that there is no significant effect of interaction between gender difference and treatment with respect to their attitudes toward science as a school subject, when PRE-ATT. and TOLT scores are controlled as covariates, ANCOVA was used. Table 5.4 gives the interaction effect on students' understanding of photosynthesis and respiration in plants. The results showed that there was no significant effect of interaction between gender difference and treatment on students' attitudes toward science as a school subject ($F(2,87)=0.285$; $p>0.05$).

5.3 Conclusions

In the light of the findings obtained by the statistical analyses, the results could be summarized as follows:

1. 5E learning cycle based instruction caused a significantly better acquisition of scientific conceptions related to photosynthesis and respiration in plants than traditional instruction.
2. Conceptual change text based instruction caused a significantly better acquisition of scientific conceptions related to photosynthesis and respiration in plants than traditional instruction.

3. No significant difference was found between 5E learning cycle based instruction and conceptual change text based instruction with respect to the understanding of photosynthesis and respiration in plants.
4. The effect of instruction on students' attitudes toward science as a school subject was not significant.
5. Reasoning abilities had a significant contribution to the students' understanding of photosynthesis and respiration in plants.
6. The difference between mean scores of males and females was not significant with respect to their understanding of photosynthesis and respiration in plants. Gender difference did not significantly affect students' understanding of photosynthesis and respiration in plants.
7. The effect of gender difference on students' attitudes toward science as a school subject was not significant.

CHAPTER VI

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter includes; discussion of the results, implications of the study and recommendations for further research.

6.1 Discussion

The purpose of this study was to investigate the effects of 5E learning cycle based instruction, conceptual change text based instruction and traditional instruction on 8th grade students' understanding of photosynthesis and respiration in plants and on their attitudes toward science as a school subject.

The descriptive statistics of the study showed that students' have many misconceptions about photosynthesis and respiration in plants. Most of the students have misconceptions related with the definition of respiration, they stated that respiration is a chemical process which occurs only in animal cells but not in plant cells, because only animal cells need energy to live as they cannot photosynthesize. The students taught that plants get the energy they need through photosynthesis. Another misconception that the results revealed that is about the place that respiration in plants takes place in. As the results showed that the students did not give the expected answer; respiration in plants takes place in every plant cell because all living cells need energy to live. They stated that respiration in plants takes place in the cells of the roots only because only roots need energy to absorb water. They did not think that all the plant cells are alive

and need energy to live. Another misconception that students have is about the equation that represents the process of respiration in plants. Most of the students responded that carbon dioxide and water are used by the green plant to produce energy during which time glucose and oxygen waste are produced. This response reveals that students think that green plants photosynthesize to produce the energy they need. One of the most important misconceptions that the students have is about the most important benefit of photosynthesis to green plants. The students think that plants produce energy through photosynthesis so the most important benefit to green plants when they photosynthesize is the production of energy. These results were consistent with the findings of the previous research (Amir & Tamir, 1994; Aşçı, Özkan & Tekkaya, 2001; Haslam & Treagust, 1987; Tekkaya & Balcı, 2003).

Regarding the analyses results, it can be concluded that 5E learning cycle based instruction caused a better understanding of photosynthesis and respiration in plants concepts and a better elimination of related misconceptions than traditional instruction. Through the instruction designed according to 5E learning cycle, the teacher was aware of students' misconceptions and tried to eliminate these misconceptions. Since learning is a social process, students worked in groups with their friends, interaction is maximized through this way. Students also made hands-on and minds-on activities, so they actively participated in the learning process. In this strategy, in the engagement phase, the teacher asked several questions to the students in order to activate their prior knowledge. In the exploration phase, the teacher asked a question for students to explore the phenomena by themselves. Both in engagement and exploration phase students had an opportunity to discuss with their friends. In this learning environment students became aware of their existing conceptions and they tried to make connections between the new concepts and the existing ones. Both in engagement phase and exploration phase the teacher had an opportunity to find out students' existing conceptions related with photosynthesis and respiration in plants.

Discussion is mostly used through all phases to increase student-student and student-teacher interaction. Students applied the newly learned concepts into new situations in the elaboration phase. Evaluation and assessment of students' knowledge is made through the instruction and if the teacher realized misconceptions. In the evaluation phase the teacher asked several questions to students to look for whether they gained the necessary concepts or not. Roundhouse diagrams were also used for this purpose. By using this tool the teacher can detect students' misconceptions. The teacher examined the roundhouse diagrams that the students filled in and observed that students gained the necessary concepts.

Conceptual change text based instruction caused a significantly better understanding of photosynthesis and respiration in plants than traditional instruction. The results are consistent with the previous research (Alparslan, Tekkaya & Geban, 2003; Çetin, 2003; Hewson & Hewson, 1983; Niaz, 2002; Özkan, Tekkaya & Geban, 2004; Smitj, Blakeslee & Anderson, 1993; Sungur, Tekkaya & Geban, 2001; Pabuçcu, 2004). There may be several reasons behind this conclusion; to design conceptual change texts Posner et al.'s (1982) instructional theory was used. According to this theory, learners must become dissatisfied with their existing conceptions and find new concepts intelligible, plausible, and fruitful. By using conceptual change texts during the instruction students' preconceptions and misconceptions are activated, and through explanations and examples scientifically correct concepts are given. Instead of giving blocks of information to the students, the text gave small bits of information and focused on the alternative conceptions of the students. By this way students' misconceptions related with photosynthesis and respiration in plants are eliminated.

In the light of the results obtained from analysis, it can be concluded that traditional instruction is less effective than 5E-LCBI and CCTBI to eliminate students' misconceptions related with photosynthesis and respiration in plants.

There may be several reasons; First, traditional instruction in the study did not focus on students' misconceptions. The teacher was not aware of students' misconceptions and she did not have any idea how to eliminate them. The traditional instruction was teacher-centered; the teacher explained the concepts and the students were passive through the instructional process. Even, the experiments were conducted as a demonstration. On the other hand, traditional instruction did not facilitate conceptual change because, students were passive learners and they did not construct their own knowledge. Traditional instruction was not effective to eliminate students' misconceptions. In 5E learning cycle based instruction and conceptual change text based instruction students were actively involved in the learning process and constructed their own knowledge. This might cause the difference in the concept test scores in traditional instruction versus 5E learning cycle based instruction and conceptual change text based instruction.

Furthermore, this study investigated the effect of treatment; 5E learning cycle based instruction, conceptual change text based instruction and traditional instruction, on students' attitudes toward science as a school subject. No significant differences were found among the effects of treatments. That is, the treatments developed similar attitude toward science as a school subject. Cukrowska, Staskun and Schoeman (1999) claimed that attitudes are not easily changed. Because the three week duration of the study is short to observe changes in the attitudes' toward science, the type of treatment may not have affected the attitudes toward science lessons differently.

Moreover, the results of this study also investigated that, there is no significant difference between boys and girls with respect to their understanding of photosynthesis and respiration in plants concepts and their attitudes toward science as a school subject. The reason why no significant difference was found in this study might be due to the fact that since the students had similar

backgrounds or experience. This situation might also affect their attitudes toward science; consequently, in this no significant difference was found between boys and girls in terms of their attitudes toward science.

To sum up, this study showed that students have misconceptions about photosynthesis and respiration in plants concepts. These misconceptions affect further learning negatively. Therefore, teachers must identify students' misconceptions and design instructions to enhance students' understanding of photosynthesis and respiration in plants. Traditional instruction does not seem effective in developing conceptual understanding of photosynthesis and respiration in plants. On the contrary, 5E learning cycle based instruction and conceptual change text based instruction are effective to eliminate students' misconceptions and enhance understanding of photosynthesis and respiration in plants.

6.2 Implications

Results of the present study had some implications for science teachers, educators and the researchers.

1. Students have several misconceptions about photosynthesis and respiration in plants concepts. These misconceptions are serious obstacles and affect further learning negatively. So, teachers must be aware of students' misconceptions and design their lessons to eliminate these misconceptions.

2. It is important to determine students' misconceptions before the instruction. Teachers should determine students' misconceptions by using diagnostic tests, at least they should ask several questions to

identify students' preconceptions, and then they should design their lesson in the light of these misconceptions.

3. Traditional instruction is less effective than 5E learning cycle based instruction and conceptual change text based instruction to enhance students' understanding of science concepts. Teachers should use instructional techniques that promote students understanding such as; 5E learning cycle based instruction and conceptual change text based instruction.

4. Teachers should be aware of students' attitudes toward science as a school subject and try to enhance students' positive attitudes.

5. School administrators should encourage teachers to use 5E learning cycle based instruction and conceptual change text based instruction.

6. Logical thinking abilities are strong predictors of understanding of science concepts. Teachers should design the lessons to develop reasoning abilities of students.

7. Teachers should be trained about constructivist instructional techniques such as; 5E learning cycle based instruction and conceptual change text based instruction.

6.3. Recommendations

On the basis of the findings of the study, the researcher recommends that;

This study can be conducted with a larger sample size.

A study can be carried out for different grade levels and different science courses to investigate the effectiveness of 5E learning cycle based instruction and conceptual change text based instruction.

Further study can be conducted in different schools to get more accurate results and to provide a generalization for Turkey.

Other constructivist teaching strategies such as bridging analogies approach can be used.

Similar research studies can be conducted to show the effects of 5E learning cycle based instruction and conceptual change text based instruction on other variables, such as science process skills.

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APPENDIX A

MANTIKSAL DÜŞÜNME YETENEK TESTİ

AÇIKLAMA: Bu test, çeşitli alanlarda, özellikle Fen ve Matematik dallarında karşılaşabileceğiniz problemlerde neden-sonuç ilişkisini görüp, problem çözme stratejilerini ne derece kullanabileceğinizi göstermesi açısından çok faydalıdır. Bu test içindeki sorular mantıksal ve bilimsel olarak düşünmeyi gösterecek cevapları içermektedir.

NOT: Soru Kitapçığı üzerinde herhangi bir işlem yapmayınız ve cevaplarınızı yalnızca cevap kağıdına yazınız. CEVAP KAĞIDINI doldururken dikkat edilecek hususlardan birisi, 1 den 8 e kadar olan sorularda her soru için cevap kağıdında iki kutu bulunmaktadır. Soldaki ilk kutuya sizce sorunun uygun cevap şıkkını yazınız, ikinci kutucuğa yani AÇIKLAMASI yazılı kutucuğa ise o soruyla ilgili soru kitapçığındaki Açıklaması kısmındaki şıkları okuyarak sizce en uygun olanını seçiniz. Örneğin 12'nci sorunun cevabı sizce b ise ve Açıklaması kısmındaki en uygun açıklama ikinci şık ise cevap kağıdını aşağıdaki gibi doldurun:

12. [b] AÇIKLAMASI [2]

9. ve 10. soruları ise soru kitapçığında bu sorularla ilgili kısımları okurken nasıl cevaplayacağınızı daha iyi anlayacaksınız.

SORU 1: Bir boyacı, aynı büyüklükteki altı odayı boyamak için dört kutu boya kullandığına göre sekiz kutu boya ile yine aynı büyüklükte kaç oda boyayabilir?

a. 7 oda

b. 8 oda

c. 9 oda

d. 10 oda

e. Hiçbiri

Açıklaması:

1. Oda sayısının boya kutusuna oranı daima $\frac{3}{2}$ olacaktır.
2. Daha fazla boya kutusu ile fark azalabilir.
3. Oda sayısı ile boya kutusu arasındaki fark her zaman iki olacaktır.
4. Dört kutu boya ile fark iki olduğuna göre, altı kutu boya ile fark yine iki olacaktır.
5. Ne kadar çok boyaya ihtiyaç olduğunu tahmin etmek mümkün değildir.

SORU 2: On bir odayı boyamak için kaç kutu boya gerekir? (Birinci soruya bakınız)

a. 5 kutu

b. 7 kutu

c. 8 kutu

d. 9 kutu

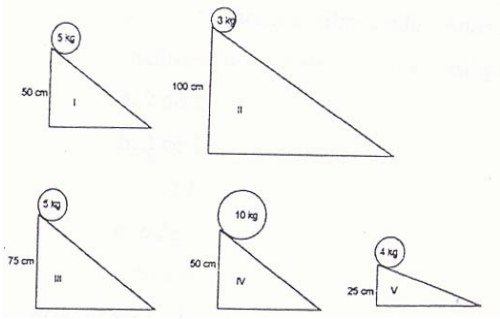
e. Hiçbiri

Açıklaması:

1. Boya kutusu sayısının oda sayısına oranı daima $\frac{2}{3}$ dür.
2. Eğer beş oda daha olsaydı, üç kutu boya daha gerekecekti.

3. Oda sayısı ile boya kutusu arasındaki fark her zaman ikidir.
4. Boya kutusu sayısı oda sayısının yarısı olacaktır.
5. Boya miktarını tahmin etmek mümkün değildir.

SORU 3: Topun eğik bir düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafe ile eğik düzlemin yüksekliği arasındaki ilişkiyi bulmak için deney yapmak isterseniz, aşağıda gösterilen hangi eğik düzlem setlerini kullanırdınız?

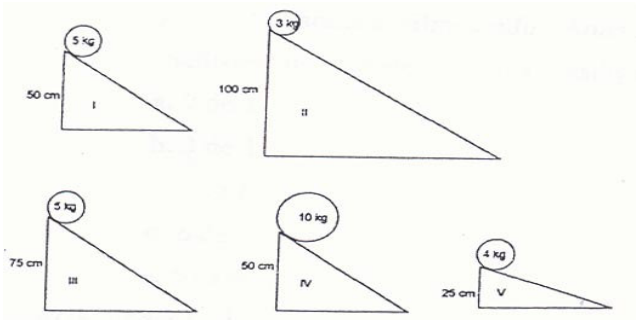


a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

Açıklaması:

1. En yüksek eğik düzlemle (rampa) karşı en alçak olan karşılaştırılmalıdır.
2. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.
3. Yükseklik arttıkça topun ağırlığı azalmalıdır.
4. Yükseklikler aynı fakat top ağırlıkları farklı olmalıdır.
5. Yükseklikler farklı fakat top ağırlıkları aynı olmalıdır.

SORU 4: Tepeden yuvarlanan bir topun eğik düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafenin topun ağırlığıyla olan ilişkisini bulmak için bir deney yapmak isterseniz, aşağıda verilen hangi eğik düzlem setlerini kullanırdınız?



a. I ve IV

b. II ve IV

c. I ve III

d. II ve V

e. Hepsi

Açıklaması:

a. En ağır olan top en hafif olanla kıyaslanmalıdır.

b. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.

c. Topun ağırlığı arttıkça, yükseklik azaltılmalıdır.

d. Ağırlıklar farklı fakat yükseklikler aynı olmalıdır.

e. Ağırlıklar aynı fakat yükseklikler farklı olmalıdır.

SORU 5: Bir Amerikalı turist Şark Expresi'nde altı kişinin bulunduğu bir kompartımana girer. Bu kişilerden üçü yalnızca İngilizce ve diğer üçü ise yalnızca Fransızca bilmektedir. Amerikalının kompartımana ilk girdiğinde İngilizce bilen biriyle konuşma olasılığı nedir?

a. 2 de 1

b. 3 de 1

c. 4 de 1

d. 6 da 1

e. 6 da 4

Açıklaması:

1. Ardarda üç Fransızca bilen kişi çıkabildiği için dört seçim yapmak gerekir.

2. Mevcut altı kişi arasından İngilizce bilen bir kişi seçilmelidir.

3. Toplam üç İngilizce bilen kişiden sadece birinin seçilmesi yeterlidir.

4. Kompartımandakilerin yarısı İngilizce konuşur.
5. Altı kişi arasından, bir İngilizce bilen kişinin yanısıra, üç tanede Fransızca bilen kişi seçilebilir.

SORU 6: Üç altın, dört gümüş ve beş bakır para bir torbaya konulduktan sonra, dört altın, iki gümüş ve üç bakır yüzük de aynı torbaya konur. İlk denemede torbadan altın bir nesne çekme olasılığı nedir?

a. 2 de 1
b. 3 de 1
c. 7 de 1
d. 21 de 1
e. Yukarıdakilerden hiçbiri

Açıklaması:

1. Altın, gümüş ve bakırdan yapılan nesneler arasından bir altın nesne seçilmelidir.
2. Paraların $\frac{1}{4}$ ü ve yüzüklerin $\frac{4}{9}$ u altından yapılmıştır.
3. Torbadan çekilen nesnenin para ve yüzük olması önemli olmadığı için toplam 7 altın nesneden bir tanesinin seçilmesi yeterlidir.
4. Toplam yirmi bir nesneden bir altın nesne seçilmelidir.
5. Torbadaki 21 nesnenin 7 si altından yapılmıştır.

SORU 7: Altı yaşındaki Ahmet'in şeker almak için 50 lirası vardır. Bakkaldaki kapalı iki şeker kutusundan birinde 30 adet kırmızı ve 50 adet sarı renkte şeker bulunmaktadır. İkinci bir kutuda ise 20 adet kırmızı ve 30 adet sarı şeker vardır. Ahmet kırmızı şekerleri sevmektedir. Ahmet'in ikinci kutudan kırmızı şeker çekme olasılığı birinci kutuya göre daha fazla mıdır?

a. Evet
b. Hayır

Açıklaması:

1. Birinci kutuda 30, ikincisinde ise yalnızca 20 kırmızı şeker vardır.
2. Birinci kutuda 20 tane daha fazla sarı şeker, ikincisinde ise yalnızca 10 tane daha fazla sarı şeker vardır.
3. Birinci kutuda 50, ikincisinde ise yalnızca 30 sarı şeker vardır.
4. İkinci kutudaki kırmızı şekerlerin oranı daha fazladır.
5. Birinci kutuda daha fazla sayıda şeker vardır.

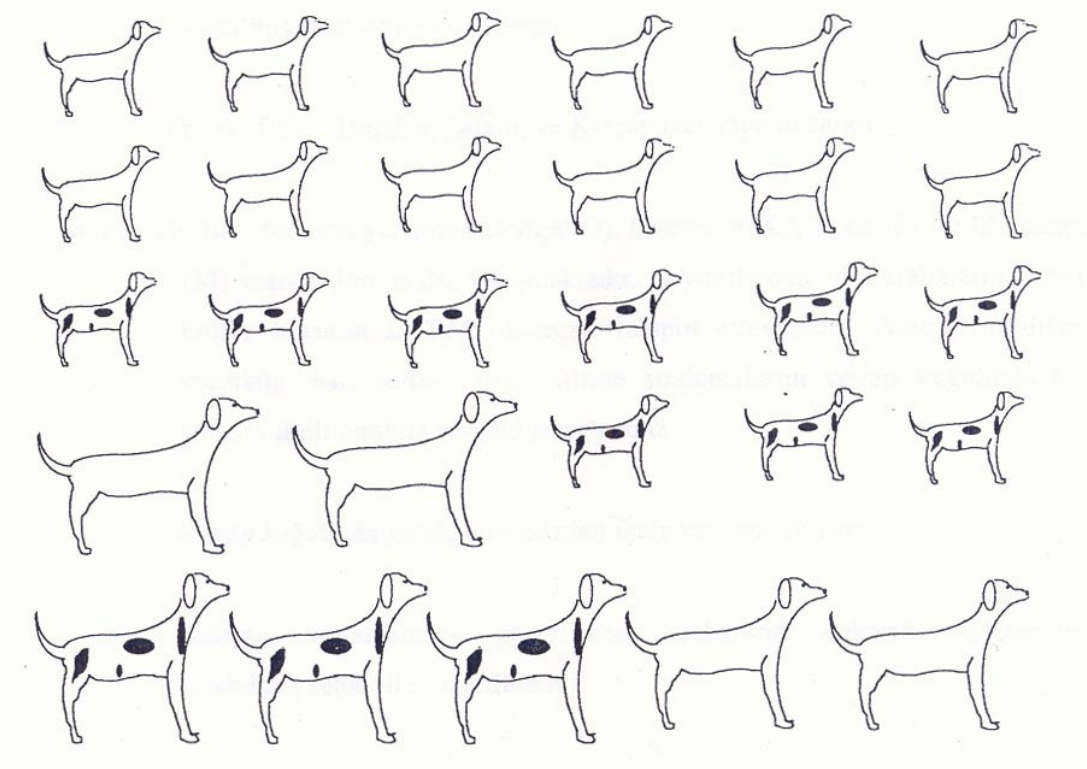
SORU 8: 7 büyük ve 21 tane küçük köpek şekli aşağıda verilmiştir. Bazı köpekler benekli bazıları ise beneksizdir. Büyük köpeklerin benekli olma olasılıkları küçük köpeklerden daha fazla mıdır?

a. Evet

b. Hayır

Açıklaması:

1. Bazı küçük köpeklerin ve bazı büyük köpeklerin benekleri vardır.
2. Dokuz tane küçük köpeğin ve yalnızca üç tane büyük köpeğin benekleri vardır.
3. 28 köpekten 12 tanesi benekli ve geriye kalan 16 tanesi beneksizdir.
4. Büyük köpeklerin $\frac{3}{7}$ si ve küçük köpeklerin $\frac{9}{21}$ i beneklidir.
5. Küçük köpeklerden 12 sinin, fakat büyük köpeklerden ise sadece 4ünün beneği yoktur.



SORU 9: Bir pastanede üç çeşit ekmek, üç çeşit et ve üç çeşit sos kullanılarak sandviçler yapılmaktadır.

Ekmek Çeşitleri	Et Çeşitleri	Sos Çeşitleri
Buğday (B)	Salam (S)	Ketçap (K)
Çavdar (Ç)	Piliç (P)	Mayonez (M)
Yulaf (Y)	Hindi (H)	Tereyağı (T)

Her bir sandviç ekmek, et ve sos içermektedir. Yalnızca bir ekmek çeşidi, bir et çeşidi kullanılarak kaç çeşit sandviç hazırlanabilir?

Cevap kağıdı üzerinde bu soruyla ilgili bırakılan boşluklara bütün olası sandviç çeşitlerinin listesini çıkarın.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Listeyi hazırlarken ekmek, et ve sos çeşitlerinin yukarıda gösterilen kısaltılmış sembollerini kullanınız.

Örnek: BSK= Buğday, Salam ve Ketçap dan yapılan sandviç

SORU 10: Bir otomobil yarışında Dodge (D), Chevrolet (C), Ford (F) ve Mercedes (M) marka dört araba yarışmaktadır. Seyircilerden biri arabaların yarışı bitiriş sırasının DCFM olacağını tahmin etmektedir. Arabaların diğer mümkün olan bütün yarışı bitirme sıralamalarını cevap kağıdında bu soruyla ilgili bırakılan boşlukalara yazınız.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Bitirme sıralamalarını gösterirken, arabaların yukarıda gösterilen kısaltılmış sembollerini kulanınız.

Örnek: DCFM yarışı sırasıyla önce Dodge'nin, sonra Chevrolet'in, sonra Ford'un ve en sonra Mercedes'in bitirdiğini gösterir.

APPENDIX B

FOTOSENTEZ VE BİTKİLERDE SOLUNUM KAVRAM TESTİ

13 sorudan oluşan bu test, fotosentez ve bitkilerde solunum konuları üzerine bilginizi ölçmektedir. Her soru iki bölümden oluşmaktadır. Birinci bölüm, konu bilgisini içeren çoktan seçmeli soruyu; ikinci bölüm ise olası nedenleri içermektedir. Her soru için bir cevap ve her cevap için bir neden işaretlemeniz gerekmektedir.

Hiçbir soruyu boş bırakmayınız.

Teşekkür ederim**.**

SORULAR

1- Yeşil bitkilerin güneş ışığında büyük miktarlarda açığa çıkardıkları gaz hangisidir?

(1) Karbon dioksit

(2) Oksijen

Çünkü;

(a) yeşil bitkiler sadece gündüz solunum yaptıkları için bu gaz güneş enerjisinin varlığında açığa çıkar.

(b) bu gaz yeşil bitkiler tarafından açığa çıkarılır çünkü yeşil bitkiler gündüzleri sadece fotosentez yaparlar solunum yapmazlar.

(c) yeşil bitkinin solunum ve diğer işlemler için ihtiyacı olandan daha fazlası fotosentez sırasında yeşil bitkiler tarafından üretilir, ihtiyaç fazlası gaz açığa çıkar.

(d) bu gaz yeşil bitkiler fotosentez yaptıktan sonra açığa çıkan bir atık üründür.

(e) _____

2- Hangi gaz yeşil bitkiler tarafından güneş enerjisi yokken büyük miktarda kullanılır?

(1) Karbon dioksit

(2) Oksijen

Çünkü;

(a) bu gaz yeşil bitkilerde her zaman gerçekleşen fotosentez için kullanılır.

(b) bu gaz yeşil bitkiler tarafından güneş enerjisi yokken yapılan fotosentez için kullanılır.

(c) bu gaz fotosentez yapmak için güneş enerjisi yokken gerçekleşen solunum için kullanılır.

(d) bu gaz yeşil bitkilerde her zaman gerçekleşen solunum için kullanılır.

(e) _____

3- Hangi gaz yeşil bitkiler tarafından güneş enerjisi yokken büyük miktarlarda açığa çıkar?

(1) Karbon dioksit

(2) Oksijen

Çünkü;

(a) yeşil bitkiler güneş enerjisi yokken fotosentez yapmazlar, fakat solunum yapmaya devam ederler ve bu yüzden bu gazı açığa çıkarırlar.

(b) bu gazı, yeşil bitkiler güneş enerjisi yokken meydana gelen fotosentez sırasında açığa çıkarırlar.

(c) yeşil bitkiler sadece ışık enerjisi yokken solunum yapabildikleri için bu gazı açığa çıkarırlar.

(d) _____

4- Aşağıdaki gazlardan hangisi güneş enerjisinin varlığında yeşil bitkiler tarafından büyük miktarda alınır?

(1) Karbon dioksit

(2) Oksijen

Çünkü;

(a) yeşil bitkiler güneş enerjisinin varlığında bu gazı kullanarak besinlerini yaparlar.

(b) hayvanlar güneş enerjisinin varlığında solunum yapmak için bu gaza ihtiyaç duyarlar.

(c) _____

5- Bitkilerde solunum nerede gerçekleşir?

(1) Sadece kök hücrelerinde

(2) Bütün bitki hücrelerinde

(3) Sadece yaprak hücrelerinde

Çünkü;

(a) bütün canlı hücrelerin yaşamak için enerjiye ihtiyacı vardır.

(b) sadece yapraklar gaz değişim işlemi için gerekli olan gözeneklere (stomalara) sahiptir.

(c) sadece kökler gaz değişim işlemi için gereken küçük deliklere sahiptir.

(d) sadece köklerin topraktan su emmek için enerjiye ihtiyacı vardır.

(e) _____

6- Solunum nedir?

(1) Bütün bitki ve hayvan hücrelerinde meydana gelen kimyasal bir işlemdir.

(2) Bitki hücrelerinde gerçekleşen fakat hayvan hücrelerinde gerçekleşmeyen kimyasal bir işlemdir.

(3) Sadece hayvan hücrelerinde gerçekleşen ama bitki hücrelerinde gerçekleşmeyen kimyasal bir işlemdir.

Çünkü;

(a) sadece bitki hücreleri yaşamak için enerjiyi bu şekilde elde ederler.

(b) bütün bitki ve hayvan hücreleri bu işlem sayesinde enerji sağlarlar.

(c) sadece hayvan hücreleri yaşamak için enerjiye ihtiyaç duyarlar çünkü hayvan hücreleri fotosentez yapamazlar.

(d) _____

7- Aşağıdakilerden hangisi yeşil bitkilerde solunumu açıklayan en doğru cümledir?

(1) Solunum bitkilerin su ve karbon dioksit kullanarak besin ürettiği kimyasal bir işlemdir.

(2) Solunum besinlerde toplanan enerjinin oksijen kullanılarak açığa çıkarıldığı kimyasal bir işlemdir.

(3) Solunum bitkilerdeki stomalar tarafından karbon dioksit ve oksijen gazlarının yer değiştirmesi işlemidir.

(4) Solunum, yeşil bitkilerde fotosentez olurken gerçekleşmeyen bir işlemdir.

Çünkü;

(a) Yeşil bitkiler asla solunum yapmazlar, onlar sadece fotosentez yaparlar.

(b) Yeşil bitkiler solunum yaparken karbon dioksit alırlar ve oksijen verirler.

(c) Solunum yeşil bitkilerin yaşaması için gereken enerjiyi sağlar.

(d) Solunum sadece yeşil bitkilerde güneş enerjisi yokken gerçekleşir.

(e) _____

8- Yeşil bitkiler ne zaman solunum yaparlar?

(1) Sadece geceleri (güneş enerjisi yokken)

(2) Sadece gündüzleri (güneş enerjisi varken)

(3) Her zaman (güneş enerjisi varken veya yokken)

Çünkü;

(a) yeşil bitkilerin hücreleri gündüz fotosentez yapabilirler bu yüzden sadece akşamları solunum yaparlar.

(b) Yeşil bitkiler yaşamak için enerjiye ihtiyaç duyarlar ve solunum bu enerjiyi sağlar.

(c) Yeşil bitkiler solunum yapmaz, onlar sadece fotosentez yapar, ve fotosentez bitki için gereken enerjiyi sağlar.

(d) _____

9- Aşağıdaki denklemlerden hangisi bitkilerdeki solunum işlemini en iyi gösterir?

(1) glikoz + oksijen $\longrightarrow$ enerji + karbon dioksit + su

(2) karbon dioksit + su $\longrightarrow$ enerji + glikoz + oksijen

(3) karbon dioksit + su $\xrightarrow[\text{klorofil}]{\text{güneş enerjisi}}$ oksijen + glikoz

(4) glikoz + oksijen $\longrightarrow$ karbon dioksit + su

Çünkü;

(a) solunum sırasında yeşil bitkiler güneş enerjisinin varlığında glikoz oluşturmak için karbon dioksit ve su alırlar.

(b) yeşil bitkiler enerji üretmek için karbon dioksit ve su kullanırlar oksijen ve glikoz açığa çıkarırlar.

(c) Solunum sırasında yeşil bitkiler oksijen alır, karbon dioksit ve su verir.

(d) Solunum sırasında, yeşil bitkiler oksijen kullanarak glikozdan enerji elde ederler.

(e) _____

10- Aşağıdaki denklemlerden hangisi fotosentez işleminin tümünü en iyi gösterir?

(1) glikoz + oksijen $\xrightarrow[\text{güneş enerjisi}]{\text{klorofil}}$ karbon dioksit + su

(2) karbon dioksit + su $\xrightarrow[\text{güneş enerjisi}]{\text{klorofil}}$ glikoz + oksijen

(3) karbon dioksit + su $\longrightarrow$ glikoz + oksijen

Çünkü;

(a) klorofil adındaki yeşil pigment karbon dioksit ile ışık enerjisinin varlığında birleşerek glikoz ve suyu oluşturur.

(b) güneş enerjisi, klorofil içeren bitkiler tarafından karbon dioksit ve suyu birleştirip, glikoz ve oksijen oluşturmaları için kullanılır.

(c) Glikoz ve oksijen, klorofilin ve ışık enerjisinin varlığında birleşerek karbon dioksit ve suyu oluşturur.

(d) _____

11- Aşağıdaki faktörlerden hangisi fotosentez işlemi için gerekli değildir?

(1) Oksijen miktarı

(2) Karbon dioksit miktarı

(3) Klorofil miktarı

(4) Işık miktarı

Çünkü;

(a) fotosentez ışık enerjisi yokken gerçekleşebilir.

(b) klorofil veya benzeri pigmentler içermeyen bitkiler de fotosentez yapabilirler.

(c) fotosentez karbon dioksit yokken gerçekleşmez.

(d) oksijen fotosentez için gerekli değildir, oksijen fotosentezin bir yan ürünüdür.

(e) _____

12- Fotosentezin yeşil bitkiler için en önemli faydası hangisidir?

(1) Havadan karbon dioksit alınması

(2) Işık enerjisinin kimyasal enerjiye dönüşmesi

(3) Enerji üretilmesi

Çünkü;

(a) fotosentez bitkinin büyümesi için gerekli olan enerjiyi sağlar.

(b) fotosentez sırasında güneş enerjisi glikoz moleküllerinde depolanır.

(c) Fotosentez sırasında karbon dioksit yapraklardaki stomalar (gözenekler) tarafından alınır.

(d) _____

13- Aşağıdaki fotosentez ve yeşil bitkilerde solunum karşılaştırmalarından hangisi doğrudur?

	Fotosentez	Solunum
(1)	Sadece yeşil bitkilerde gerçekleşir.	Sadece hayvanlarda gerçekleşir
(2)	Bütün bitkilerde gerçekleşir.	Sadece bütün hayvanlarda gerçekleşir.
(3)	Yeşil bitkilerde ışık enerjisinin varlığında gerçekleşir.	Bütün bitkilerde ve bütün hayvanlarda her zaman gerçekleşir.
(4)	Yeşil bitkilerde ışık enerjisinin varlığında gerçekleşir.	Bütün bitkilerde ışık enerjisi yokken ve bütün hayvanlarda ise her zaman gerçekleşir.

Çünkü;

(a) yeşil bitkiler fotosentez yapar ama solunum yapmazlar.

(b) yeşil bitkiler gündüzleri fotosentez, geceleri ise solunum yaparlar (ışık enerjisi yokken).

(c) solunum bütün yaşayan canlılar için devamlı bir işlemdir. Fotosentez ise sadece ışık enerjisi varken gerçekleşir.

(d) bitkiler fotosentezden yeterli enerji elde edemezlerse solunum yaparlar (mesela akşamları) hayvanlar ise devamlı solunum yaparlar çünkü hayvanlar fotosentez yapamazlar.

(e) _____

APPENDIX C

FEN BİLGİSİ DERSİ TUTUM ÖLÇEĞİ

Bu ölçek, fen bilgisi dersine ilişkin tutum cümleleri ve her cümlenin karşısında sizin düşüncenizi ölçen beş seçenek içermektedir. Lütfen her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

		Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1)	Fen bilgisi çok sevdiğim bir alandır.	**O**	**O**	**O**	**O**	**O**
2)	Fen bilgisi ile ilgili kitapları okumaktan hoşlanırım.	**O**	**O**	**O**	**O**	**O**
3)	Fen bilgisinin günlük yaşantıda çok önemli bir yeri yoktur.	**O**	**O**	**O**	**O**	**O**
4)	Fen bilgisi ile ilgili ders problemlerini çözmekten hoşlanırım.	**O**	**O**	**O**	**O**	**O**
5)	Fen bilgisi konuları ile ilgili daha çok şey öğrenmek isterim.	**O**	**O**	**O**	**O**	**O**
6)	Fen bilgisi dersine girerken sıkıntı duyarım.	**O**	**O**	**O**	**O**	**O**
7)	Fen bilgisi dersine zevkle girerim.	**O**	**O**	**O**	**O**	**O**
8)	Fen bilgisi dersine ayrılan ders saatinin daha fazla olmasını isterim.	**O**	**O**	**O**	**O**	**O**
9)	Fen bilgisi dersine çalışırken canım sıkılır.	**O**	**O**	**O**	**O**	**O**
10)	Fen bilgisi konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.	**O**	**O**	**O**	**O**	**O**
11)	Düşünce sistemimizi geliştirmede fen bilgisi öğrenimi önemlidir.	**O**	**O**	**O**	**O**	**O**
12)	Fen bilgisi çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.	**O**	**O**	**O**	**O**	**O**
13)	Dersler içinde fen bilgisi dersi önemsiz gelir.	**O**	**O**	**O**	**O**	**O**
14)	Fen bilgisi konuları ile ilgili tartışmalara katılmak bana cazip gelmez.	**O**	**O**	**O**	**O**	**O**
15)	Çalışma zamanımın önemli bir kısmını fen bilgisi dersine ayırmak isterim.	**O**	**O**	**O**	**O**	**O**

APPENDIX D

5E ÖĞRENME MODELİNE DAYALI FOTOSENTEZ DERSİ

TEŞVİK ETMEK:

Sizce bitkilerin besini nedir?

Sizce hayvanların besini nedir?

Sorularını sorup öğrencilerden 4'lü gruplar halinde soruları tartışmalarını isteyin. Fotosentez kelimesini kullanmamaya ve bitkinin besini hakkında yorum yapmamaya özen gösterin. Öğrencilerden gelen cevaplar doğru yada yanlış da olsa yorum yapmayın.

KEŞFETMEK:

Aşağıdaki deney düzeneğini öğrencilere açıklayın ve bu düzenek hakkındaki görüşlerini gruplarıyla tartışmalarını isteyin. Sonuca varırken sizinle ve birbirleriyle tartışmalarını sağlayın. Aşağıda verilen cümleleri grup tartışmasından sonra uygun şekilde tamamlamalarını isteyin. Fotosentez kelimesini kullanmamaya ve bitkinin besini hakkında yorum yapmamaya özen gösterin. Öğrencilerden gelen cevaplar doğru yada yanlış da olsa yorum yapmayın.

Yeşil bir bitki köklerindeki topraklardan arındırıldıktan sonra 500 gr. geliyor. Bu bitki bir saksıya ekiliyor ve toprağı kuruduğunda su veriliyor ve başka hiçbir işlem yapılmıyor. Bitki 5 yıl sonra saksıdan çıkarılıp tartıldığında 4 kg. geliyor.

* Geçen 5 yıl sonunda bitki büyüdüğüne ve bu kadar ağırlaştığına göre toprağın ağırlığı hakkında ne söyleyebilirsiniz?

- Toprağın ağırlığı çok azalmıştır çünkü _____
- Toprağın ağırlığı değişmemiştir çünkü _____
- Toprağın ağırlığı artmıştır çünkü _____

* Bitkinin bu kadar büyümesinin sebebi ne olabilir?

AÇIKLAMA

Öğrencilerde fotosentez konusunda görülen kavram yanılgıları aşağıda belirtilmiştir. Konu anlatımında bu kavram yanılgılarına dikkat etmeniz gerekmektedir.

- Yeşil bitkiler fotosentez yolu ile güneş ışığını besine çevirir.
- Yeşil bitkiler fotosentez yaparak su ve karbon dioksidi oksijene çevirir.
- Bitkiler fotosentez yoluyla oksijeni karbon diokside çevirir.
- Bitkiler fotosentez yoluyla karbon dioksidi oksijene çevirir.
- Fotosentez bitkilerin enerji ürettiği bir işlemdir.

- Fotosentez bir gaz değişim işlemidir.
- Fotosentez besin transferidir.
- Fotosentez bitkinin CO_2 ve güneş ışığını kullanarak, su ve besin üretmesidir. Besini yer, suyu içer.
- Bitkiler suyu, oksijeni, ışığı ve topraktan aldıkları maddeleri fotosentez yaparak enerjiye ve karbon diokside çevirir.
- Fotosentezin yeşil bitkiler için en önemli faydası enerji üretimidir, çünkü fotosentez bitkinin gelişmesi için gereken enerjiyi sağlar.
- Fotosentez sonucunda karbon dioksit, yeşil yapraklar, ve klorofil üretilir.
- Bitkinin besini topraktır.
- Mineraller, su, karbon dioksit, ışık enerjisi ve güneş bitkinin besinidir.
- İnorganik moleküller bitkinin besinidir.
- Amino asitler ve azot bitkinin besinidir.
- Gübre bitkinin besinidir.

Aşağıda fotosentez konusuyla ilgili öneri bir anlatım bulunmaktadır. Bu anlatıma gerekli görürseniz ekleme yapabilirsiniz fakat ekleme yaparken kavram yanılgısına yol amayacak cümleler sarfetmeye özen gösterin. 1. ve 2. safhada sorulan soruları anlatım sırasında öğrencilerle tartışarak durumları keşetmelerini sağlayın.

Canlı organizmaların besine ihtiyacı vardır. Peki bu organizmalar besinlerini nasıl elde eder? ***(Hayvanların ve bitkilerin ayrı ayrı besimlerini nasıl elde ettiklerini öğrencilerle tartışın ve cevapları tahtaya yazın. Bu noktada soruların cevaplarını vermemeye özen gösterin. Sorunun cevabını öğrencilerin keşfetmesini sağlayın.)*** Eğer hayvanlardan bahsediyor olsaydık bu canlılar besin maddelerini dışarıdan hazır alırlar demek yanlış olmazdı. Çünkü hayvanlar heterotrofturlar (tüketici). Heterotrof canlılar kendi besinini üretemezler. Yaşamak, büyümek, üremek ve yaşamsal etkinliklerini gerçekleştirebilmek için

dışarıdan aldıkları besinlere ihtiyaç duyarlar. Oysa yeşil bitkiler ototrofturlar (üretici). Yani kendi besinlerini kendileri üretirler.

Peki o zaman bitkinin besini nedir? ***(Sorusunu öğrencilerle tartışın verilen cevapların hepsini tahtaya yazın. Su, karbon dioksit, gübre, mineraller, güneş ışığı gibi cevaplar gelirse öğrencilere bitkilerin üretici olduğunu ve besinini dışarıdan hazır almadığını hatırlatın.)*** Yeşil bitkiler fotosentez ile inorganik moleküllerden organik molekülleri sentezlerler. Bitkinin besini fotosentezle ürettiği glikozdur.

Fotosentez için neler gereklidir? Ve fotosentez sonrasında neler açığa çıkar ***(Soruyu öğrencilerle tartışın, verilen cevapları tahtaya yazın. Öğrencilere fotosentezi gösteren bir denklem bilip bilmediklerini sorun. Öğrencilerle birlikte fotosentez denklemini tamamlamaya çalışın.)***

Fotosentez: $6CO_2 + 6H_2O \xrightarrow[\text{klorofil}]{\text{ışık enerjisi}} C_6H_{12}O_6 + 6O_2$

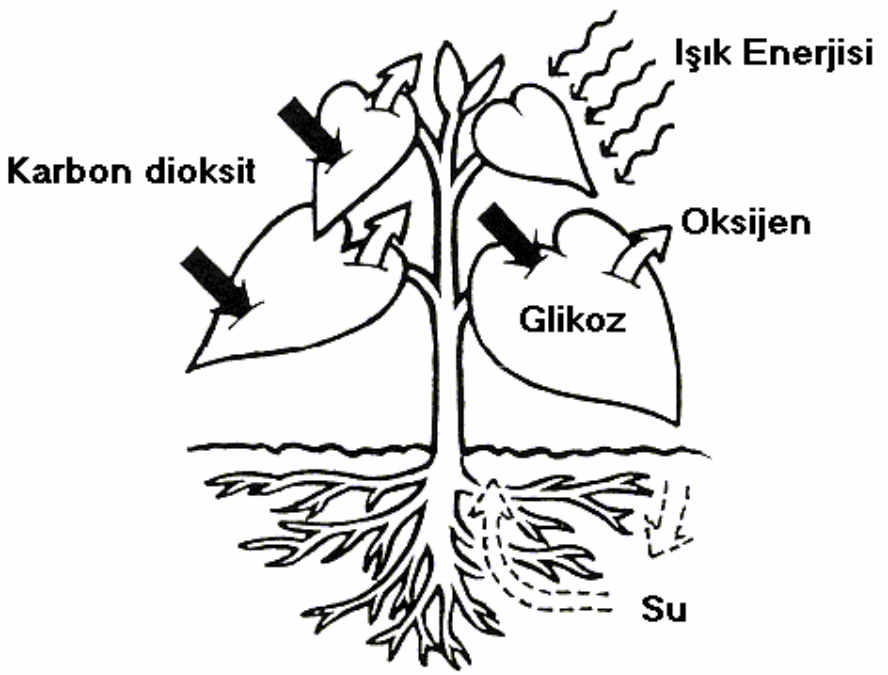
Bitkiler fotosentez için iki hammaddeye gereksinim duyarlar. Bunlar su ve karbon dioksittir. Bitkiler kökleriyle **topraktan** suyu ve suyla birlikte mineralleri emer. Su gövdeden yapraklara kadar ulaşır. Karbon dioksit **havadaki** gazlardan biridir. Karbon dioksit bitkilere yaprakların yüzeyindeki stoma adı verilen küçük gözeneklerin açılmasıyla girer. Burada şunu hatırlatmak gerekir ki su ve karbon dioksit bitkinin besini değildir. Bu maddeler fotosentez için gereken hammaddelerdir.

Fotosentez yapraklardaki kloroplastlarda yer alan **klorofillerde** gerçekleşir. Klorofil bitkiye yeşil rengini veren bir pigmenttir.

Fotosentez için **güneş enerjisi** gereklidir. Bu yüzden fotosentez sadece gündüzleri gerçekleşir geceleri yani güneş enerjisi yokken gerçekleşmez.

Fotosentezin son ürünleri şeker ve oksijendir. Üretilen oksijen yapraklardaki stomalar tarafından **havaya** verilir. Oksijen fotosentez sonucu

üretilen bir yan üründür. Fotosentezin son ürünlerinden biri olan şeker bitkinin besinidir. FOTOSENTEZİN ASIL AMACI BİTKİNİN BESİNİNİ ÜRETMESİDİR. Bir bitki ürettiği bütün şekeri kullanmaz. Bu şekeri depolamak için daha uygun olan diğer besinlere çevirir. Böylece üretilen şeker meyve, tohum ve yemişlerin içinde depo edilir. ***(Aşağıda cevapları verilmiş olan bitkilerde fotosentez işlemini gösteren şekili öğrencilerin doldurmasını isteyin.)***



Fotosentezin bitkilerin kloroplast içeren hücrelerinde gerçekleştiğini biliyorsunuz. Ancak bitkilerin köklerinde ve çoğu bitkinin gövdesinde kloroplast bulunmaz. Bitkilerin kloroplast içermeyen organlarının da besine gereksinimleri vardır. Peki bu besin bitkinin diğer kısımlarına nasıl ulaşır? ***(Soruyu öğrencilere sorduktan sonra kendi aralarında tartışmalarını isteyin. Doğru cevabı bulmaları için eski bilgilerini hatırlatacak yönlendirmeler yapabilirsiniz. "Soymuk borularının ve odun borularının görevlerini hatıralayın" gibi)*** Yapraklarda üretilen glikozun bir bölümü yapraklarda kullanılır. Kalanı ise soymuk boruları yoluyla bitkinin diğer organlarına iletilir. Bitkiler fotosentezle

ürettikleri besinlerin bir kısmını yaşamsal etkinlikleri için kullanırlar. Geriye kalan besin kök, gövde ve yapraklarında depo ederler.

GENİŞLETME:

Öğrencilerden fotosentez için gerekli hammaddeleri ve fotosentez sonucu açığa çıkan ürünleri düşünerek bunları test edebilecekleri deney düzenekleri hazırlamalarını isteyin. Aşağıda bu amaca yönelik bazı deneylerin prosedüreleri verilmiştir. Ayrıca fotosentezi başka hangi etkenlerin (sıcaklık, enzim) etkilediğini tartışın.

YAPRAKTAKİ NİŞASTAYI TEST ETMEK:

1- Sağlıklı bir bitkiden bir yaprak alınız ve su banyosundaki kaynayan su kabının içine atınız. 30 saniye kadar bekletiniz. (30 saniye sardunya için normal süre, bu süre, bitkiden bitkiye değişebilir.)

2- Yaprağı sudan çıkartınız ve yumuşamış olan yaprağı su banyosunun içindeki alkol dolu tüpün içine atınız. Bütün klorofil yapraktan çözülene kadar bekletiniz.

3- Yaprak şimdi sertleşip kırılabilir hale gelecektir. Yumuşatmak için alkolden çıkarıp tekrar suya batırınız.

4- Yaprağı beyaz bir plastik kart üzerine yayınız ve üzerini iyot çözeltisi ile örtünüz. Rengin siyaha dönmesi yaprağın nişasta içerdiğini gösterir.

FOTOSENTEZ İÇİN IŞIK GEREKLİDİR

1- Saksıda yetişen sağlıklı bir sardunya bitkisi alınız. Nişasta yapmaması için birkaç gün bir kutu içinde bırakınız.

2- Birkaç yaprağını nişasta olmadığını kontrol etmek için test ediniz.

3- Bir parça siyah kağıt yada alüminyum folyoyu yapraktan biraz büyükçe kesiniz. Folyo yada kağıdı yaprak kenarlarından ışık almayacak şekilde yaprağın bir kısmına sarınız. Yaprağı bitkiden koparmayınız.

4- Bitkiyi sıcak güneşli bir cam önünde birkaç gün bekletiniz.

5- Folyoyu nişasta kontrolü yapmak üzere çıkartınız.

FOTOSENTEZ İÇİN KARBONDİOKSİT GEREKLİDİR

1- Bir bitkiyi nişastadan arındırınız.

2- Düzeneğinizi şekil 3 de gösterildiği gibi ayarlayınız. Yaprakları içine aldığınız flasklara hava girmemesine özen gösteriniz. Bitkiyi birkaç gün sıcak güneşli bir pencere önünde bekletiniz.

3- İşleme tabi tutulan yapraklardaki nişastayı test ediniz.

FOTOSENTEZ İÇİN KLOROFİL GEREKLİDİR

1- Alacalı (yeşil ve beyaz) yaprakları olan bir bitkiyi nişastadan arındırınız.

2- Bitkiyi birkaç gün sıcak güneşli bir yerde bırakınız.

3- Yapraklardan birini nişasta için test ediniz.

FOTOSENTEZ SIRASINDA OKSİJEN ÜRETİLİR

1- Düzeneğinizi şekil de gösterildiği gibi hazırlayınız. Test tüpünün tamamıyla su solu olduğundan emin olunuz.

2- Deney düzeneğini sıcak, güneşli bir pencere önüne birkaç gün bırakınız.

3- Test tüpünü dikkatlice huninin ucundan çekerken içindeki gazı kaçırmadan suyun boşalmasına izin veriniz.

4- Küçük bir tahta çöpü yakınız ve sonra kor halinde iken söndürünüz. Test tüpünün içindeki gaza doğru dikkatlice tüpün içine sokunuz. Ne olacağını gözlemleyiniz.

DEĞERLENDİRME/SINAMA

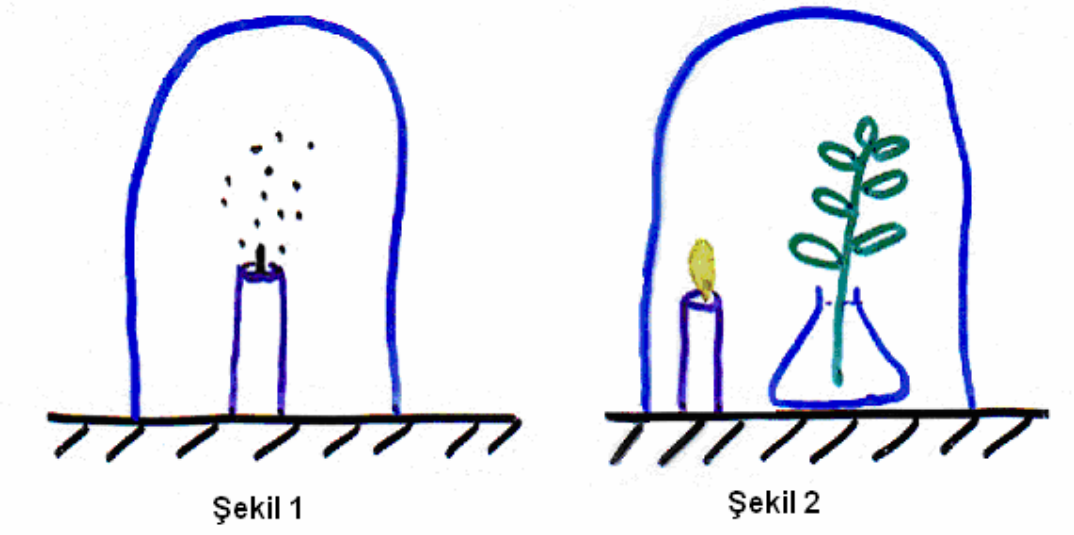
Aşağıda verilen soruları öğrencilere sorunuz. Cevapları sınıfta tartışınız. Öğrencilerin fotosentez konusu ile ilgili gerekli kavramları öğrenip öğrenmediklerini kontrol ediniz.

1- Fotosentezin yeşil bitkiler için en önemli faydası nedir?

2- Yeşil bitkiler güneş enerjisi yokken hangi gazı büyük miktarlarda kullanırlar? Neden?

3- Fotosentez nerede gerçekleşir? Üretilen besin bitkinin diğer kısımlarına nasıl iletilir?

4- Yanan bir mum bir fanusun içine konulduğunda mumun bir süre sonra söndüğü gözlemlenmiştir **(Şekil 1)**. Yanan bir mum ve bir bitki bir fanusun içine konulduğunda ise mumun yanmaya devam ettiği gözlenmiştir **(Şekil 2)**. Bu iki durum hakkında ne söyleyebilirsiniz?



Şekil 1 Şekil 2

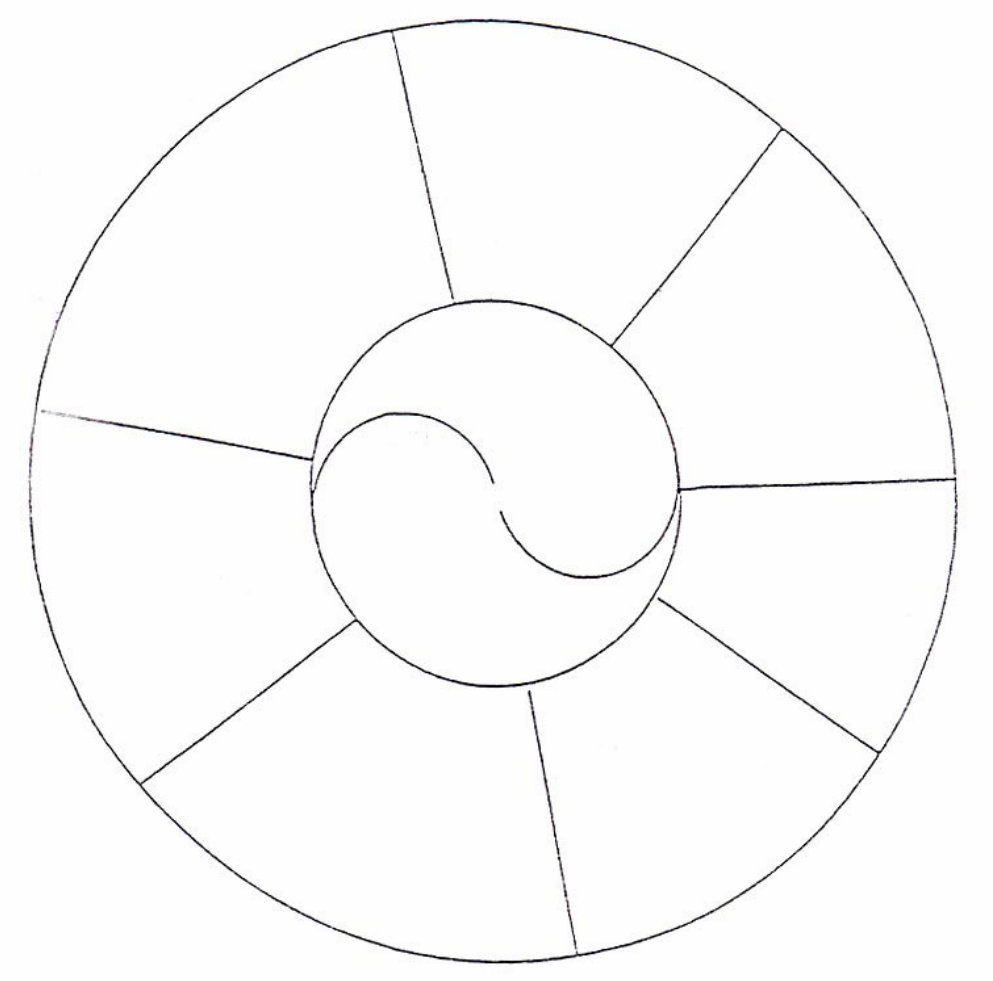
5- Aşağıda size verilen diagramı fotosentez olayını açıklamak için kullanınız.

a) Bu konuyla ilgili yazmak istadiğiniz başlığı aşağıdaki çemberin ortasındaki yere çeşitli bağlaçlar (ve/-in gibi) kullanarak yazınız.
Örn: Mitoz bölünme ve büyüme; Hücrelerin mitoz bölünmesi

b) Bu diagramı doldurmanızdaki amacı diagramın altında ayrılan alana yazınız.
Örn: Mitoz bölünmenin safhalarını daha iyi anlamak istiyorum.

c) Konu hakındaki bilgilerinizi düşününüz. Bunları sizce anlamlı parçalara bölünüz.

d) Anlamlı olduğunu düşündüğünüz her bir parçayı aşağıdaki diagramda ayrılmış parçaların içine yazınız.Her bir parçanın içine düşüncelerinizi anlatan şekiller çiziniz.



Amaç:

APPENDIX E

5E ÖĞRENME MODELİNE DAYALI YEŞİL BİTKİLERDE SOLUNUM DERSİ

TEŞVİK ETMEK:

Bütün canlıların yaşamsal faaliyetlerini devam etirmek için enerjiye ihtiyacı vardır. **Sizce canlılar bu enerjiyi hangi olay sonucunda elde ederler?**

Yukarıdaki soruyu öğrencilerin gruplar halinde tartışmalarını sağlayın. Öğrencilerden gelen cevaplar doğru yada yanlış da olsa yorum yapmayın.

KEŞFETMEK:

Aşağıdaki deney düzeneğini öğrencilere açıklayın bu konu hakkındaki görüşlerini gruplarıyla tartışmalarını sağlayın. Öğrencilerden gelen cevaplar doğru yada yanlış da olsa yorum yapmayın.

Bir öğrenci bir fanusun içine bir bitki ve bir kap içinde kireç suyu koymuştur. Bu öğrenci bu deney düzeneği ile neyi test etmeye çalışmaktadır?

Yukarıdaki deney düzeneğini güneşli ve karanlık ortamda düşünerek kireç suyunda maydana geleceğini düşündüğünüz değişiklikleri hipotez şeklinde yazınız.

(Unutmayınız ki kireç suyu karbon dioksit gazının varlığında bulanır.)

AÇIKLAMA:

Öğrencilerde bitkilerde solunum konusunda görülen kavram yanılgıları aşağıda belirtilmiştir. Konu anlatımında bu kavram yanılgılarına neden olacak cümleler sarf etmemeye özen gösterin.

- Bitkiler solunum yerine fotosentez yapar.
- Bitkiler solunum sırasında karbon dioksit kullanır.
- Bitkilerde solunumun amacı havadan karbon dioksit alıp, hayvanların kullanımı için oksijen üretmektir.
- Fotosentez yeşil bitkilerin yaptığı solunumdur.
- Fotosentez yeşil bitkilerin oksijen kullanarak yaptığı solunumdur.
- Fotosentez yeşil bitkilerin karbon dioksit kullanarak yaptığı solunumdur.
- Fotosentez yeşil bitkilerin enerji ürettiği bir işlemdir.
- Bitkilerde solunum sadece kök hücrelerinde gerçekleşir, çünkü sadece topraktan su emmek için enerjiye ihtiyaçları vardır.
- Bitkilerde solunum sadece kök hücrelerinde gerçekleşir çünkü sadece kökler gaz değişim işlemi için gereken küçük deliklere sahiptir.
- Bitkilerde solunum sadece yaprak hücrelerinde gerçekleşir çünkü sadece yapraklar gaz değişim işlemi için gerekli olan gözeneklere (stomalara) sahiptir.
- Bitkiler hiçbir zaman solunum yapmazlar.
- Bitkiler fotosentez yapmadığı zamanlar, yani geceleri, solunum yapar.

Aşağıda bitkilerde solunum konusuyla ilgili öneri bir anlatım bulunmaktadır. Bu anlatıma gerekli görürseniz ekleme yapabilirsiniz fakat ekleme yaparken

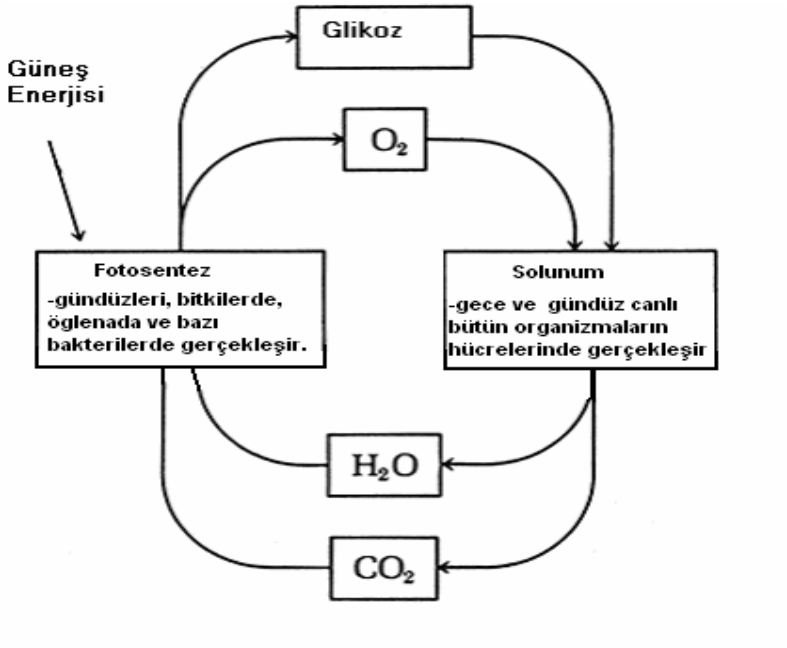
kavram yanılgısına yol açmayacak cümleler sarf etmemeye özen gösterin. ***1. ve 2. safhada sorulan soruları öğrencilerle tartışarak verilen durumları anlatım sırasında keşfetmelerini sağlayın.***

Canlılar yaşamlarını devam ettirebilmek ve bütünlüklerini koruyabilmek için enerjiye gereksinim duyarlar. Canlı organizmalardaki her hücrenin enerjiye ihtiyacı vardır. Hücreler enerjilerini SOLUNUM olayı sayesinde elde eder. Solunum, enerji bakımından zengin bileşiklerin parçalanarak organizma için gerekli enerjinin elde edilmesi olayıdır. Solunum bütün bitki hücrelerinde ve hayvan hücrelerinde gerçekleşen kimyasal bir işlemdir.

Bilindiği gibi ATP yüksek enerjili kimyasal bağlara sahip olan bir bileşiktir. Hücrede gerçekleşecek aktif taşıma, hücre bölünmesi, yeni hücre bileşiklerinin üretilmesi gibi olaylarda enerji gereksinmesinin karşılanması için ATP denilen bileşiğin kullanılması zorunludur. Bütün hücrelerde de ATP üretmenin yolu solunumdur. SOLUNUM, enerji bakımından zengin bileşiklerin parçalanarak organizma için gerekli enerjinin elde edilmesi olayıdır.

Bitklerde gerçekleşen solunumun hayvanlardakinden amaç itibariyle hiçbir farkı yoktur. Her iki canlı grubunda da temel amaç hücrelerin genel kullanımı için enerji üretmektir. Solunum bir organizmanın CANLI olan bütün hücrelerinde gerçekleşir. Solunum diğer birçok hayatsal faaliyet gibi çeşitli biyokimyasal reaksiyonların gerçekleşmesi ile olur. Bu reaksiyonlar da hücre içinde gerçekleşir. Yeşil bitkilerde solunum bütün bitki hücrelerinde gerçekleşir çünkü bütün canlı hücrelerin yaşamak için enerjiye ihtiyacı vardır.

Fotosentez ve solunum farklı amaçlar için yapılan olaylardır, dolayısı ile bir bitki hücresinin fotosentez yapmaması onun solunum yapmamasını gerektirmez. O anda bitki hücresi fotosentez yapsa da yapmasa da solunum yapmak durumundadır. Sonuç olarak diyebiliriz ki bitkilerde ve diğer bütün canlılarda solunum **her zaman** gerçekleşir.



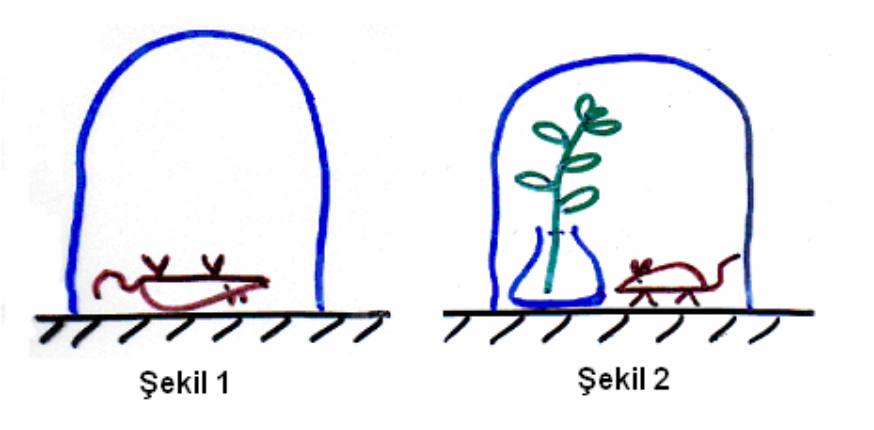
GENİŞLETMEK:

Öğrencilerinizin doğadaki karbon dioksit ve oksijen dengesini ve bu dengeyi bozacak etkenleri tartışmalarını isteyebilirsiniz. Küçük grup tartışmaları bu noktada etkili olacaktır. Öğrencilerinizin öğrendikleri kavramları yeni durumlara uygulayıp uygulayamadıklarını gözlemleyebilirsiniz. Gerekli görürseniz bazı kavramlar üzerinde tekrar durabilirsiniz.

DEĞERLENDİRME:

Aşağıda verilen soruları öğrencilere sorunuz. Cevapları sınıfta tartışınız. Öğrencilerin bitkilerde solunum konusu ile ilgili gerekli kavramları öğrenip öğrenmediklerini kontrol ediniz.

1- Fanusun içine konulan bir farenin bir süre sonra öldüğü gözlenmiştir **(Şekil 1).** Bir bitki ve bir fare benzer bir fanusun içine konulduğunda **(Şekil 2)** fare yaşamını sürdürebilir mi? Yanıtınızı açıklayınız.



2- Yeşil bitkiler ne zaman solunum yapar? Yanıtınızı açıklayınız.

3- Aşağıda her bir şıkta verilen kelimeleri kullanarak bu kavramlar arasında nasıl bir ilişki olduğunu cümleler kurarak açıklamaya çalışınız.

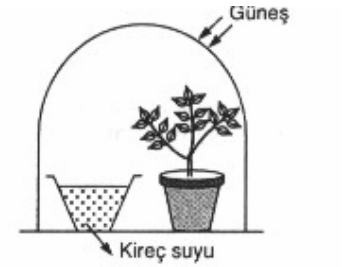
a) Solunum, fotosentez, enerji

b) Fotosentez, güneş ışığı, besin

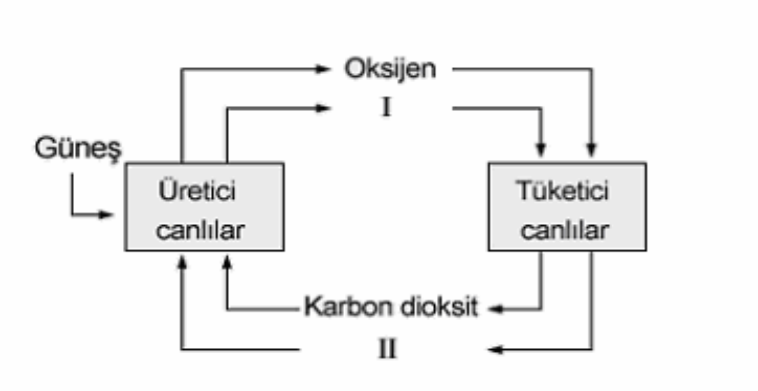
c) Solunum, enerji, besin

d) Glikoz, besin, enerji

4- Karbon dioksitli ortamda bulunan kireç suyu bulanır. Bu prensibi kullanarak bitkilerin solunum sırasında karbon dioksit verdiğini göstermek isteyen bir öğrenci aşağıdaki düzeneği kurmuştur. Öğrenci kurduğu düzenekte kireç suyunun **<u>bulanmadığını</u>** gözlemiştir. Bu deneyde öğrencinin beklediği etkiyi gözlemesini ne engellemiş olabilir? Yanıtınızı açıklayınız.



5- Aşağıda verilen üretici-tüketici canlılar arasındaki **I** ve **II** ile gösterilen yerlere yazılması gerekenler aşağıdaki şıklarda verilenlerden hangisidir?



	I	**II**
a)	Karbon dioksit	Besin
b)	Besin	Oksijen
c)	Besin	Su
d)	Su	Karbon dioksit

6- Buğday bitkisi, solunum için dışarıdan yaprakları ile hangisini alır?

a) Su

b) Besin

c) Oksijen

d) Karbon dioksit

7- Aşağıda size verilen diagramı bitkilerde solunum olayını açıklamak için kullanınız.

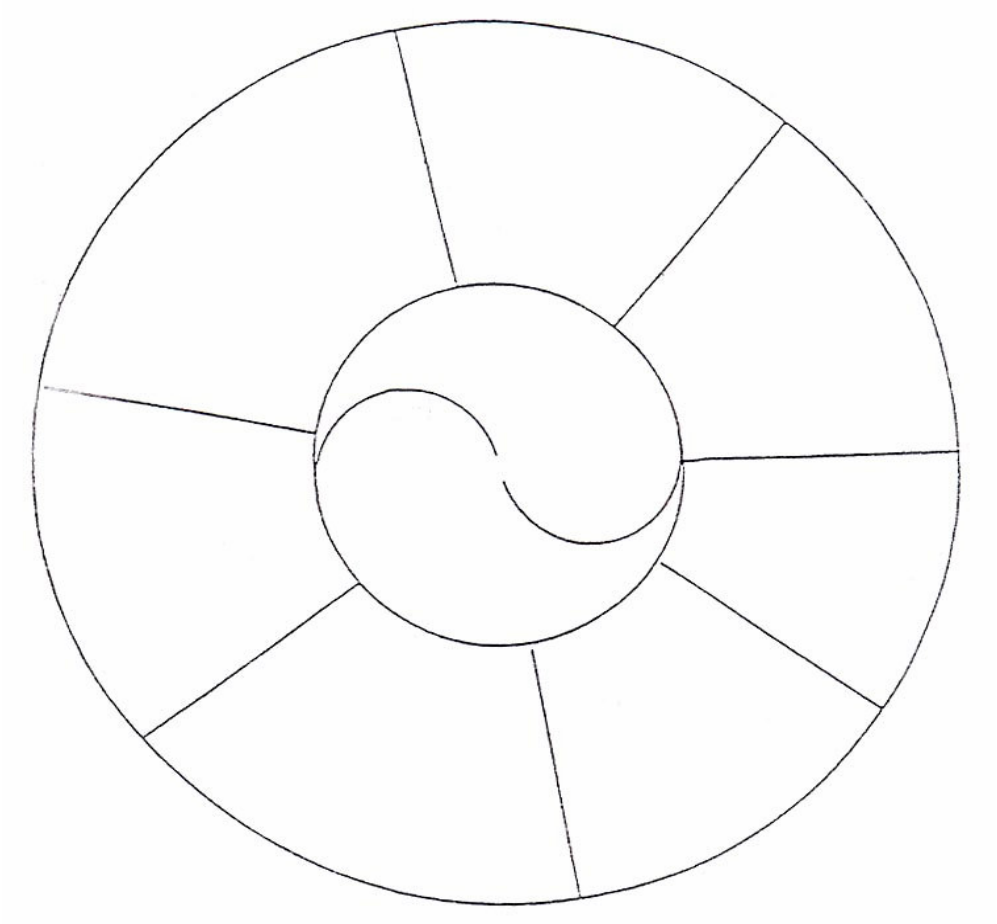
a) Bu konuyla ilgili yazmak istediğiniz başlığı aşağıdaki çemberin ortasındaki yere çeşitli bağlaçlar (ve/-in gibi) kullanarak yazınız.
Örn: Mitoz bölünme **ve** büyüme; Hücreler**in** mitoz bölünmesi

b) Bu diagramı doldurmanızdaki amacı diagramın altında ayrılan alana yazınız.
Örn: Mitoz bölünmenin safhalarını daha iyi anlamak istiyorum.

c) Konu hakkındaki bilgilerinizi düşününüz. Bunları sizce anlamlı parçalara bölünüz.

d) Anlamlı olduğunu düşündüğünüz her bir parçayı aşağıdaki diagramda ayrılmış parçaların içine yazınız.

e) Her bir parçanın içine düşüncelerinizi anlatan şekiller çiziniz.



Amaç:

APPENDIX F

KAVRAMSAL DEĞİŞİM METNİ I

BİTKİLERİN BESİNİ NEDİR?

Bu sorunun yanıtını yeşil bitkiler ile ilgili bildiklerimiz hakkında biraz düşünerek bulabiliriz. Yeşil bitkinin besini nedir diye sorulduğunda bazı öğrenciler aşağıdaki cevapları vermişlerdir.

☹ Yeşil bitkinin besini topraktır.

☹ Mineraller, su, karbon dioksit, ışık enerjisi ve güneş yeşil bitkinin besinidir.

☹ İnorganik moleküller yeşil bitkinin besinidir.

☹ Amino asitler ve azot yeşil bitkinin besinidir.

☹ Gübre yeşil bitkinin besinidir.

Sizce yeşil bitkinin besini nedir? Bu konudaki bilgileriniz, yukarıda sıralananlarla uyuşuyor mu?

☹ Bilimsel gerçeklikten farklı olarak birçok öğrenci bitkilerin de hayvanlar gibi çevresinden aldığı maddelerle beslendiklerini düşünmektedir. Bu öğrencilere göre yeşil bitkinin besini dışarıdan aldığı su, karbon dioksit, mineraller, ışık enerjisi, güneş, amino asitler, azot, gübre gibi maddelerdir.

Sizde yeşil bitkinin besini nedir sorusunu tekrar düşündükten sonra aşağıdaki açıklamayı okuyunuz.

☺ Canlı organizmaların besine ihtiyacı vardır. Peki bu organizmalar besinlerini nasıl elde eder? Eğer hayvanlardan bahsediyor olsaydık bu canlılar besin maddelerini dışarıdan hazır alırlar demek yanlış olmazdır. Çünkü hayvanlar heterotrofturlar (tüketici). Heterotrof canlılar kendi besinlerini kendileri üretirler.

☺ Peki o zaman bitkinin besini nedir? Bitkinin besini fotosentezle ürettiği glikozdur. Yeşil bitkiler fotosentez ile inorganik moleküllerden organik molekülleri sentezlerler. Bitkiler fotosentez sırasında oluşturduğu gikozun fazlasını nişasta gibi karbonhidratlar şeklinde kök, gövde ve yapraklarında depolarlar. Yaşamsal faaliyetleri için gereksinim duydukça depoladıkları bu karbonhidratları solunum yaparak enerji elde etmede kullanırlar.

☺ Bitkiler ÜRETİCİDİRLER çünkü kendi besinlerini FOTOSENTEZLE üretirler. BİTKİNİN BESİNİ KENDİ ÜRETTİĞİ GLİKOZDUR.

Şimdi bu bilgileri kullanarak fotosentezin tanımını yapmaya çalışalım. Fotosentez bazı öğrenciler tarafından aşağıdaki biçimlerde tanımlanmıştır:

☹ Yeşil bitkinin glikozu, güneş ışığını, klorofili ve karbon dioksiti kullanarak bunları besine çevirmesidir.

☹ Yeşil bitkilerin güneş ışığı, CO_2 ve gerekli besinlerle kendi besinini yapmasıdır.

☹ Yeşil bitkinin güneş ışığı yardımıyla beslenmesidir.

☹ Yeşil bitkinin yemek yapmasıdır.

☹ Yeşil bitkinin güneş ışığını besine çevirmesidir.

☹ Yeşil bitkiler fotosentez yolu ile güneş ışığını besine çevirir.

☹ Yeşil bitkiler fotosentez yaparak su ve karbon dioksiti oksijene çevirir.

☹ Yeşil bitkiler fotosentez yoluyla karbon dioksiti oksijene çevirir.

☹ Fotosentez yeşil bitkilerin enerji ürettiği bir işlemdir.

☹ Fotosentez yeşil bitkilerin oksijen alarak besinlerini ürettiği bir işlemdir.

☹ Fotosentez bir gaz değişim işlemidir.

☹ Fotosentez besin transferidir.

☹ Fotosentez yeşil bitkinin CO_2 ve güneş ışığını kullanarak, su ve besin üretmesidir.

☹ Fotosentez sonucunda karbon dioksit, yeşil yapraklar, ve klorofil üretilir.

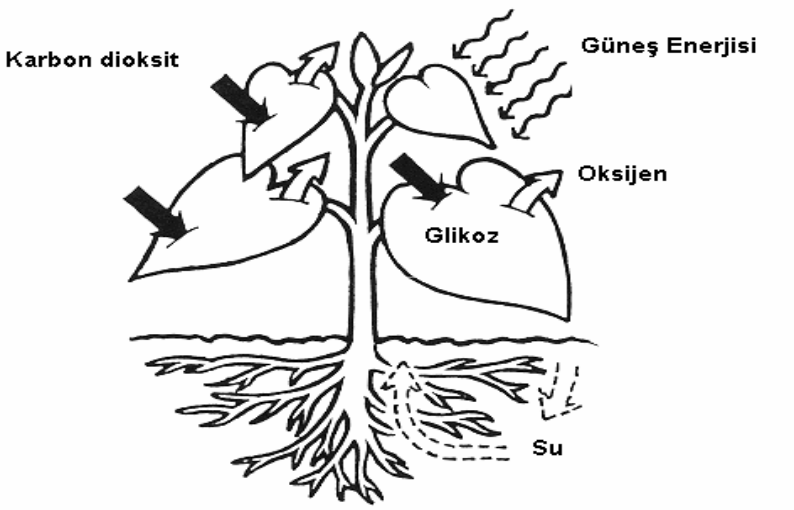
Size göre fotosentez nedir? Bu konudaki bilgileriniz, yukarıda sıralananlarla uyuşuyor mu?

☹ Bilimsel gerçeklikten farklı olarak birçok öğrenci fotosentezi sadece karbondioksitin ve suyun alınarak oksijen ve glikoza dönüştürüldüğünü düşünmektedir. Bu öğrenciler fotosentezi bir gaz değişim işlemi olarak görüp güneş ışığı ve klorofili göz ardı etmektedirler.

Siz de kafanızdaki fotosentez tanımını tekrar düşündükten sonra bilimsel şekliyle fotosentezin tanımını okuyunuz:

☺ Fotosentez; güneş ışığının enerji kaynağı olarak kullanılmasıyla karbondioksit ve su gibi inorganik maddelerden organik maddelerin üretilmesine denir. Fotosentez için bitki iki tane ham maddeye gereksinim duyar. Bunlar su ve karbon dioksittir. Bitkiler kökleriyle topraktan suyu ve suyla birlikte mineralleri emer. Su gövdeden yapraklara taşınır. Karbon dioksit ise yaprakların yüzeyindeki stoma adı verilen küçük gözeneklerin açılmasıyla girer. Fotosentez kloroplastlarda bulunan bitkiye yeşil rengini veren klorofillerde gerçekleşir. Tepkimeler sonrasında bitkinin besini olan glikoz ve bir yan ürün olan oksijen açığa çıkar. Fotosentezin gerçekleşebilmesi için güneş enerjisine ihtiyaç vardır.

Bitkiler GECELERİ FOTOSENTEZ YAPMAZLAR! Fotosentezin asıl amacı BİTKİNİN İHTİYACI OLAN BESİNİ OLUŞTURMAKTIR. Oksijen sadece bir yan üründür.



☺ FOTOSENTEZ güneş ışığının enerji kaynağı olarak kullanılmasıyla karbondioksit ve su gibi inorganik maddelerden organik maddelerin üretilmesine denir. Bu esnada oksijen de açığı çıkmaktadır. Fotosentez kloroplastlarda bulunan bitkiye yeşil rengini veren klorofillerde gerçekleşir. BİTKİLER FOTOSENTEZLE KENDİ BESİNLERİNİ ÜRETİRLER.

FOTOSENTEZ VE BİTKİLERDE SOLUNUM

Fotosentez ile solunum canlılık için çok önemli iki hayatsal faaliyettir. Bu iki olay arasında sizce nasıl bir ilişki vardır?

Bazı öğrenciler bu soruyu aşağıdaki biçimlerde yanıtlamışlardır:

☹ Fotosentez solunumun tersidir.

☹ Fotosentez yeşil bitkilerin karbon dioksit kullanarak yaptığı solunumdur.

☹ Fotosentez yeşil bitkilerin karbon dioksit alıp, oksijen vererek solunum görevini yerine getirmesidir.

☹ Fotosentez yeşil bitkilerin solunumudur.

☹ Fotosentez yeşil bitkinin güneş ışığında yaptığı solunumdur.

☹ Fotosentez yeşil bitkilerin yaptığı oksijenli solunumdur.

Size göre sorunun cevabı nedir?.... Neden?

☹ Birçok öğrenci fotosentez ile solunumu birbirinin tersi faaliyetler olarak değerlendirmektedir. Bunun temel sebebi fotosentez reaksiyonları için karbondioksite ihtiyaç duyulması ve oksijeninin üretilmesi; solunum için ise oksijene ihtiyaç duyulması ve karbondioksit üretilmesi durumudur. Peki bu reaksiyonların bu gazları gerektirip üretmeleri dışında, başka özellikleri yok mudur?

Siz de kafanızda bu sorudan sonra oluşan düşünceleri tekrar gözden geçirdikten sonra bilimsel şekliyle sorunun cevabını okuyunuz:

☺ Fotosentez ile solunum arasında bir ilişki yoktur. Bir başka deyişle bunlar ne aynı amaç için yapılan birbirinin çeşidi olaylar; ne de birbirlerinin tersi şeklinde gerçekleşen olaylardır. Fotosentez olayında amaç **organik madde** (örn: glikoz) üretmek, solunum olayındaki amaç ise **enerji** üretmektir.

Aşağıda fotosentezi ve solunumu gösteren denklemleri beraber inceleyelim.

Fotosentez: $CO_2 + H_2O \xrightarrow[\text{klorofil}]{\text{ışık enerjisi}} C_6H_{12}O_6 + O_2$

Solunum: $C_6H_{12}O_6 + 6O_2 \xrightarrow[su]{enzim} 6CO_2 + 6H_2O + enerji$

Verilen denklemlerden de görüldüğü gibi fotosentez ve solunum farklı olaylardır.

☺ Solunum ile fotosentez birbirine benzer veya birbirinin zıttı olan olaylar değildir. Farklı amaçlar için yapılan olaylardır.

APPENDIX G

KAVRAMSAL DEĞİŞİM METNİ II

YEŞİL BİTKİLERDE SOLUNUM

Sizce yeşil bitkilerde solunumu nasıl açıklayabiliriz? Öğrendiklerimizi düşünerek bu soruya bir yanıt vermeye çalışalım.

Bazı öğrenciler bu soruyu aşağıdaki biçimlerde yanıtlamışlar:

☹ Bitkiler solunum yerine fotosentez yapar.

☹ Bitkiler solunum sırasında karbondioksit kullanır.

☹ Bitkilerde solunumun amacı havadan karbondioksit alıp, hayvanların kullanımı için oksijen üretmektir.

☹ Fotosentez yeşil bitkilerin yaptığı solunumdur.

☹ Fotosentez yeşil bitkilerin oksijen kullanarak yaptığı solunumdur.

☹ Fotosentez yeşil bitkilerin karbon dioksit kullanarak yaptığı solunumdur.

☹ Fotosentez yeşil bitkilerin enerji ürettiği bir işlemdir.

☹ Bu öğrenciler solunumu ve fotosentezi birbirine karıştırmaktadır. Fotosentez reaksiyonları esnasında karbondioksitin harcanması ve oksijenin açığa çıkması, bu öğrencilerin fotosentezi de bir çeşit solunum sanmalarına neden olmaktadır.

Yukarıda sorulmuş olan sorunun cevabını tekrar düşündükten sonra aşağıdaki paragrafı okuyunuz:

☺ Bilimsel anlamıyla fotosentez güneş ışığını enerji kaynağı olarak kullanılmasıyla karbondioksit ve su gibi inorganik maddelerden organik maddelerin üretilmesine denir. Bu esnada oksijen de açığa çıkmaktadır. Fakat asıl amaç besin (örn: Glikoz) üretmektedir.

☺ Canlılar yaşamlarını devam ettirebilmek ve bütünlüklerini koruyabilmek için enerjiye gereksinim duyarlar. Canlı organizmalardaki her hücrenin enerjiye ihtiyacı vardır. Hücreler enerjilerini SOLUNUM olayı sayesinde elde eder. Solunum, enerji bakımından zengin bileşiklerin parçalanarak organizma için gerekli enerjinin elde edilmesi olayıdır. Solunum bütün bitki hücrelerinde ve hayvan hücrelerinde gerçekleşen kimyasal bir işlemdir.

Bilindiği gibi ATP yüksek enerjili kimyasal bağlara sahip olan bir bileşiktir. Hücrede gerçekleşecek aktif taşıma, hücre bölünmesi, yeni hücre bileşiklerinin üretilmesi gibi olaylarda enerji gereksinmesinin karşılanması için ATP denilen bileşiğin kullanılması zorunludur. Bütün hücrelerde de ATP üretmenin yolu solunumdur.

Fotosentez ve solunum farklı amaçlarla yapılan işlemlerdir. Bütün canlı hücreler enerji gereksinimlerini solunumla karşılarlar.

☺ SOLUNUM, enerji bakımından zengin bileşiklerin parçalanarak organizma için gerekli enerjinin elde edilmesi olayıdır. SOLUNUM OLAYININ AMACI ENERJİ ÜRETMEKTİR. Solunum bütün bitki ve hayvan hücrelerinde gerçekleşen kimyasal bir olaydır.

☺ Bitkilerde gerçekleşen solunumun hayvanlardakinden amaç itibariyle hiçbir farkı yoktur. Her iki canlı grubunda da temel amaç hücrelerin genel kullanımı için enerji üretmektir.

YEŞİL BİTKİLERDE SOLUNUM NEREDE GERÇEKLEŞİR?

Sahip olduğunuz bilgilere göre bu soruyu cevaplamaya çalışınız… Bazı öğrenciler bu soruya aşağıdaki yanıtları vermişlerdir.

☹ Bitkilerde solunum sadece kök hücrelerinde gerçekleşir çünkü sadece köklerin topraktan su emmek için enerjiye ihtiyaçları vardır.

☹ Bitkilerde solunum sadece kök hücrelerinde gerçekleşir çünkü sadece kökler gaz değişim işlemi için gereken küçük deliklere sahiptir.

☹ Bitkilerde solunum sadece yaprak hücrelerinde gerçekleşir çünkü sadece yapraklar gaz değişim işlemi için gerekli olan gözeneklere (stomalara) sahiptir.

☹ Bu öğrenciler yeşil bitkilerde solunumun bitkinin belirli kısımlarında örn.yaprak ve köklerde gerçekleştiğini düşünmektedir.

Yukarıda sorulmuş olan sorunun sizce cevabı nedir? Tekrar düşündükten sonra aşağıdaki paragrafı okuyunuz:

☺ Solunum bir organizmanın CANLI olan bütün hücrelerinde gerçekleşir. Solunum diğer birçok hayatsal faaliyet gibi çeşitli biyokimyasal reaksiyonların gerçekleşmesi ile olur. Bu reaksiyonlar da hücre içinde gerçekleşir. Yeşil bitkilerde solunum bütün bitki hücrelerinde gerçekleşir çünkü bütün canlı hücrelerin yaşamak için enerjiye ihtiyaçları vardır.

☺ Canlı hücreler yaşamak için enerjiye ihtiyaç duyarlar. Hücreler bu enerjiyi solunum sayesinde elde ederler. Bütün canlı hücrelerde solunum gerçekleşir.

YEŞİL BİTKİLERDE SOLUNUM NE ZAMAN GERÇEKLEŞİR?

Bu sorunun yanıtını bitkileri ele alarak cevaplamaya çalışalım. Sahip olduğunuz bilgilere göre bu soruyu cevaplamaya çalışınız…Bazı öğrenciler bu soruya aşağıdaki yanıtları vermişlerdir:

☹ Bitkiler hiç bir zaman solunum yapmazlar.

☹ Bitkiler fotosentez yapmadıkları zaman solunum yaparlar.

☹ Bitkilerde solunum yalnızca gece olur.

☹ Bitkiler belli zamanlarda solunum yapar.

☹ Bitkiler fotosentez yapmadığı zamanlar, yani geceleri, solunum yapar.

☹ Bazı öğrenciler fotosentezin ve solunumun aynı anda olamayacağını, bitkilerde ve hayvanlarda solunumun birbirinden farklı zamanlarda gerçekleştiğini, hayvanlarda solunumun devamlı ama bitkilerde sadece geceleri gerçekleştiğini düşünmektedirler.

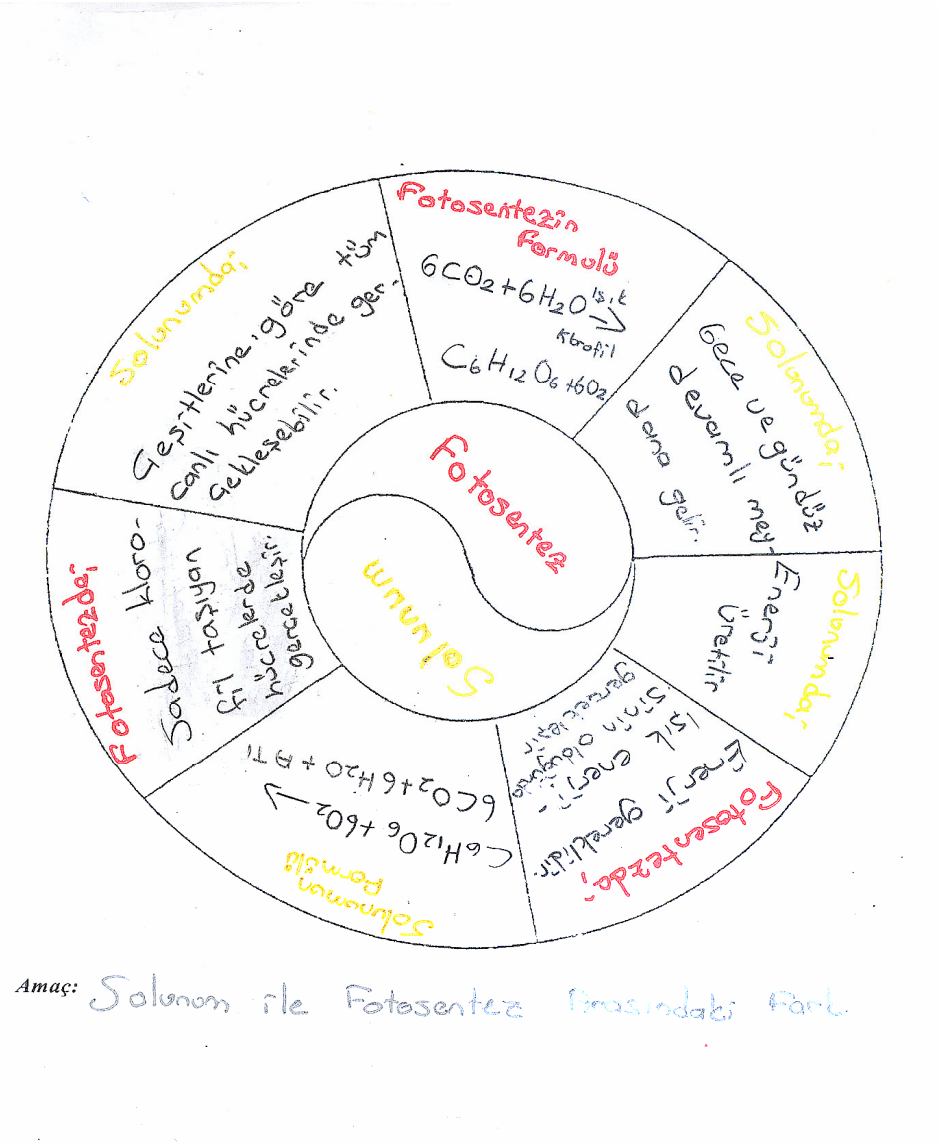
Yukarıda sorulmuş olan sorunun sizce cevabı nedir? Tekrar düşündükten sonra aşağıdaki paragrafı okuyunuz:

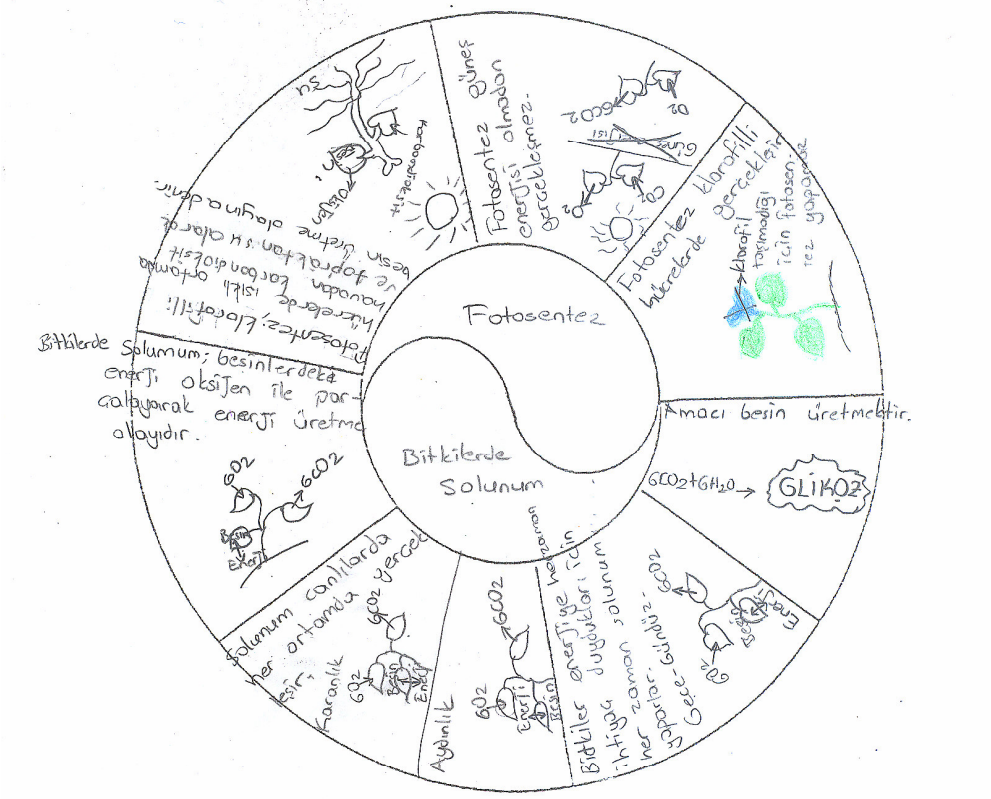
☺ Fotosentez ve solunum farklı amaçlar için yapılan olaylardır, dolayısı ile bir bitki hücresinin fotosentez yapması onun solunum yapmamasını gerektirmez. O anda bitki hücresi fotosentez yapsa da yapmasa da solunum yapmak durumundadır. Sonuç olarak diyebiliriz ki bitkilerde ve diğer bütün canlılarda solunum **her zaman** gerçekleşir.

☺ SOLUNUM, bitki ve hayvan hücrelerinde **her zaman** gerçekleşir.

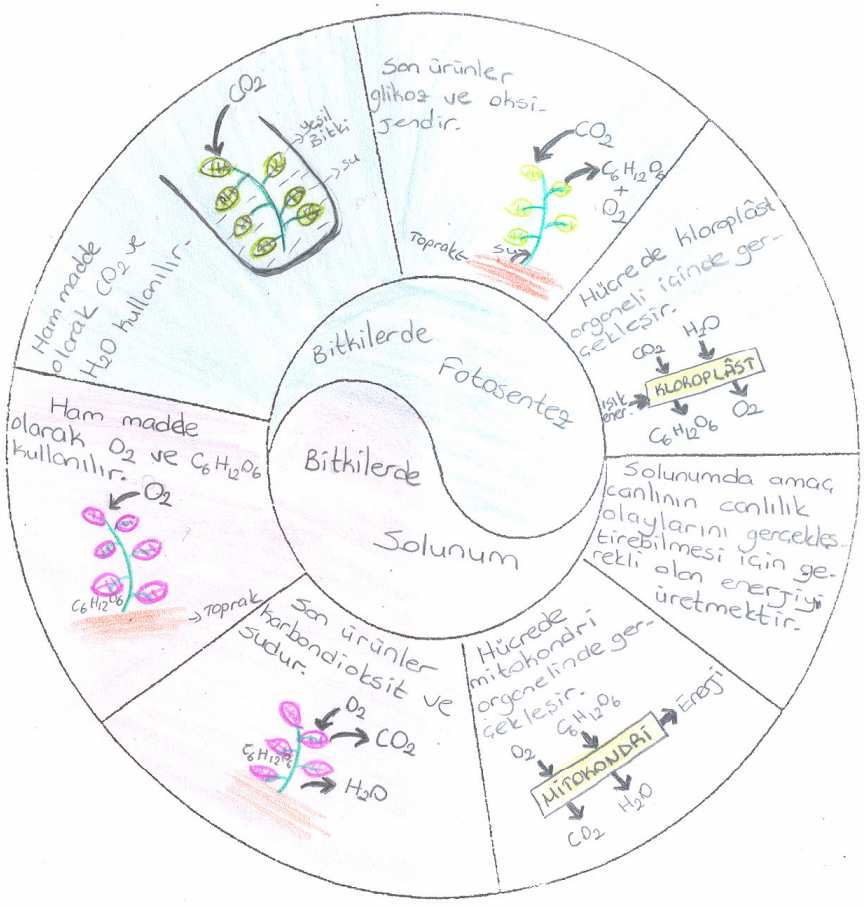
APPENDIX H

KAVRAM ÇARKI ÖRNEKLERİ



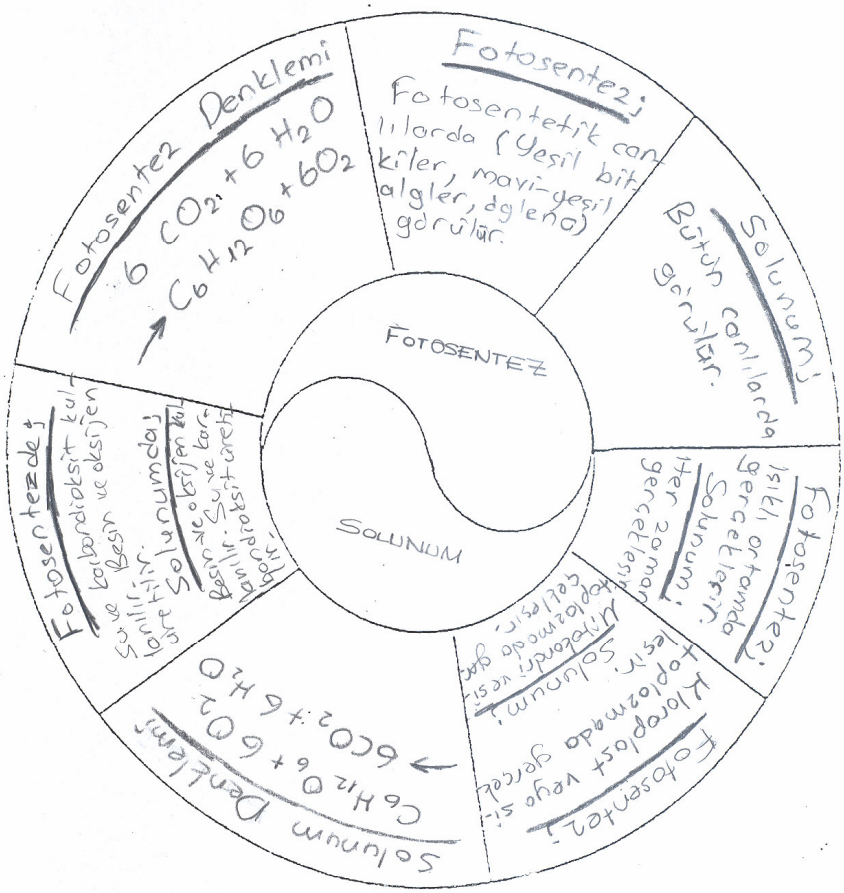


Amaç: Fotosentez ile Solunum arasındaki farkları şekillerle göstererek anlamak genel amaçtır.



Amaç:

Fotosentez ve solunum olaylarının hücrenin hangi kısımlarda gerçekleştiğini, amaçlarını ve kullanılan maddelerin neler olduğunu kavramak.



Amaç: Solunum ve Fotosentez arasındaki farklar.