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SECONDARY SCHOOL STUDENTS' UNDERSTANDING OF ENERGY FLOW IN ECOSYSTEMS

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Abstract

Understanding of energy flow concepts in ecosystems is one prerequisite area among students for good performance in biology education. The pattern and trends in biology subject performance in Kenyan national examinations, has revealed apparent complexity in understanding such concepts in ecology. The study therefore assessed secondary school students' understanding of energy flow concepts in the ecosystems at Kenyan ordinary level curriculum. The study focused on ecology, a subject area taught at form three study level under the current Kenyan 8-4-4 education system. The target population was form three students drawn from western Kenya secondary schools. The sample frame was selected from form three students across secondary schools that had enrolled for examinable biology subject. A descriptive analysis was employed to characterize and determine students understanding of energy flow and loss in the ecosystems. Findings from the study revealed resultant generation of alternative outcomes in learning and understanding energy flow concepts in ecosystems. Further, it revealed that student's conceptualize living organisms as separate individuals which exist in ecosystems. In addition, students could not relate interdependence of several components of an ecosystem such as animals, plants, gases, food and minerals and the amount of energy transferred across trophics.

Key words: Ecology, Learning, Energy flow, Ecosystems, Alternative Concepts

1.1 Introduction

There are limited research reports into secondary school students' understanding ideas concerning ecosystems. According to report entitled Strengthening Mathematics and Science Education by collaborative Kenya-Japan project, (SMASSE, 2003); inappropriate teaching methods and approaches, were revealed to be the contributing reasons for poor understanding and performance of students in science and mathematics education. The findings in the report revealed that; learning was mainly teacher-centred. In previous studies related to this area under study, researchers concentrated specifically on students' understanding of fundamental biological concepts such as inheritance, human biology, natural selection, human circulatory system, nutrient cycling in ecosystems while neglecting enegy flow concepts in ecosystems (Adeniyi, 1985).

Kenya National Research Council, (2012), stipulates important concepts regarding energy flow through an ecosystem and are outlined in the National research council report principles for life sciences. According to these principles, elementary students should develop an understanding of the interrelationships between biotic and abiotic factors in an environment. In addition, elementary students should be able to explain the feeding relationships between groups of organisms, such as producers and consumers, and develop the ability to predict accurately how a change in one population could affect other populations within the ecosystems.

According to Webb and Bolt (1990), conceptual difficulties relating to energy flow through an ecosystem are not limited to students in the elementary and middle school grades, but also, students in high school and colleges also demonstrate difficulties in understanding ecology concepts. Majority of the high school and college students studied could predict the probable effect on one organism in a food chain when a second organism was removed, but they could not successfully predict the effect on an entire food web if one population was eliminated. The study recommended for professional development of programs that can be an effective approach for helping in-service teachers improves their science content knowledge and delivery (Supovitz and Turner, 2000). However, in order to develop effective programs, it is important to identify specific standards-based concepts that are troublesome for students (Louks-Horsley, *et al (*1996).

According to Kenya National Examination Council (KNEC) reports, the main reason for poor understanding of science content among learners; is ineffectiveness of skills such as lesson

preparation and presentation during practical lessons. The report further cited over-reliance on laboratory assistants by most trained teachers as well as preference of lecture method during teaching science (KNEC, 2005). The report further indicated that, participation of students in programs such as intuitive science congress was minimal in many up-coming schools. This was attributed to minimal guidance of students by teachers who failed to come up with viable projects and presentations aimed at aiding students in understanding scientific concepts.

The report recommended for effective understanding of science concepts in secondary schools, general ideas of a subject should be presented first and then progressively differentiated in terms of detail and specificity. Instructional materials should attempt to integrate new material with previously presented information through comparisons and cross-referencing of new and old ideas (KNEC, 2006).

Mental constructivism theory propounded by Ausubel (1963), learning must start with issues around which students are actively trying to construct meaning. Meaning requires understanding whole as well as parts. Therefore, learning process should focus on primary concepts and not isolated facts. The author asserted that for well coordinated teaching, it is imperative to understand the mental models that students use to perceive the world and the assumptions they make to support those mental models. According to Piaget, (1929) assimilation occurs when new experiences are aligned and integrated in individuals' already existing framework and perception of the world. Accommodation on the other hand is the process of reframing ones mental representation of the external world to fit in new experiences (Piaget, 1929)

Related to this study, Khatete (1985), in his study entitled working with Kenyan children in every day context, the author examined children's ideas about decomposition, food spoilage and the scientific basis of food preservation. The study summarily suggested that children possessed misconceptions on decomposition and its importance in nature. The study therefore concluded that, these misconceptions were passed on to children by peers, parents, teachers and other generations' members. Furthermore, Adeyini (1985) in his studies on common misconceptions held by junior secondary school students revealed that students possess several alternative conceptions about food chain, energy flow, pyramid of energy and the carbon cycle.

This study therefore adopted the advance organizers scheme (Figure 1) basing on constructivism in presenting a framework on how learning and conception takes place. Expository method involves describing the new content by teachers to students; Skimming and illustrating, meant breaking down meaning into concepts before teaching; and Graphic organizers method helps learning concepts presented with aid of pictographs, descriptive patterns and concept patterns to help in learning and understanding.

1.2 Methods

The study focused on determining secondary school students' conception of energy flow in ecosystems. The study sampled twenty secondary schools from target thirty six secondary schools in Lugari district, of western Kenya. Further, one hundred and fifty form three students were selected from target four hundred form three students in sampled Lugari district of Kenya. Form three students were selected to participate in the study on the basis that these concepts are taught at that level of Kenyan 8.4.4 biology syllabus.

Students were exposed to test items containing images and statements on ecosystems concepts (Figure 5, 6, 7). The learners responded to the four questions of the study; such as, "What is the source of energy in ecosystems in the image presented? "What are various modes of energy loss and transfer in ecosystems in the illustration?" "What is the meaning and significance of arrows in the food chain ecosystems presented?" "What is the degree of agreement/disagreement with the following concepts of energy flow in ecosystems?

1.3 Results and Discussion

Results in Figure 2 demonstrated that students had varied interpretations of the illustrative energy flow diagrams and statements presented to them. A notable number of the students, 25.3% responded that 10% of energy was lost from one tropic level to the next. Further, 90% of students either did not respond to questions or avoided making choices to questions presented. .

The results in Figure 3 indicated that 54.7% correctly understood that energy is lost from producers to consumers; whereas 44.6% got it wrong that energy is lost from decomposers to abiotic chemicals. The study sought to reveal students understanding of food chain arrows and

significance of arrows in food chains. Students were further presented with pictorial presentations in their questionnaire to sketch.

It was revealed by 42.4% students had correct scientific understanding of importance of direction of arrows in food chain in ecosystems, whereas 36.8% of students demonstrated weaknesses in understanding scientific basis behind the direction of the arrows in food chain by wrongly indicating on the food chain provided(Figure 4). However, 55.7% of students demonstrated correct understanding of the significance of arrows on the food chain correctly by sketching correctly that arrows indicate the flow of energy in ecosystem.

The study further sought to reveal students' held alternative understanding of energy flow in ecosystems (Table 1). Students were presented with questions in form of Likert scale statements Table 1 bearing both (correct and incorrect concepts). This was to address to a question 'What is alternative understanding of energy flow in ecosystems among students?

In reference to the statements one and two in Table 1, it was revealed that a minimal number of students 29.6% got it wrong that 90 – 100% of energy is transferred to next trophic level against the conventional understanding that 9-10% of energy that is transferred in ecosystems. Further, majority of students 53.6% competently disagreed in support of misconception statements on energy flow in ecosystems. In conclusion, there was a higher percentage 74.4% of students who agreed with fact that solar energy is the main source of energy in the ecosystems and that energy is transferred from the predator to the prey.

1.4 Discussion

Based on the data analyzed and presented, it was revealed that students through learning and understanding ecology concepts had acquired knowledge that, sun was the main source of energy in ecosystems. Most students in the study had a correct conception on general interaction of population of organisms in their ecosystems; however their explanations of relationships were merely descriptive in nature, basing on their choices of various concepts presented to them. The findings are similar to study conducted by Strommen (1995) which revealed that students defined forest using forest animals such as lion, tiger, and bear and the place where these animals. Results presented revealed failure by students to show understanding of nutritional relationships, particularly in terms of energy flow in ecosystems. In similar study, it was

concluded that students could not grasp the possibility of cross nutritional relationships among animals (Sherpardson, 2005). Further studies revealed that a student who do not know the concept of decomposer and soil relationship may form an idea such that soil takes in dead plants and animals and destroys them (Braund, 1998). Similarly, in the present study, student could not express the amount of energy transferred from one trophic to another. According to Tunnicliffe and Reiss (2000) students tend to express activities of decomposers in soil by imaginary ideas, and strongly express what they observe vividly in their explanations.

1.5 Conclusion

Findings from the study revealed resultant generation of alternative conceptions in learning and understanding energy flow concepts in ecosystems such as importance of direction food chain arrow and its significance. Further, it revealed that student's conceptualize living organisms as separate individuals or entities which exist in ecosystems. It was noted that students could not relate interdependence of several components of an ecosystem such as animals, plants, gases, food and minerals and the amount of energy transferred across trophics.

Acknowledgement

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1.6 APPENDICES

Figures

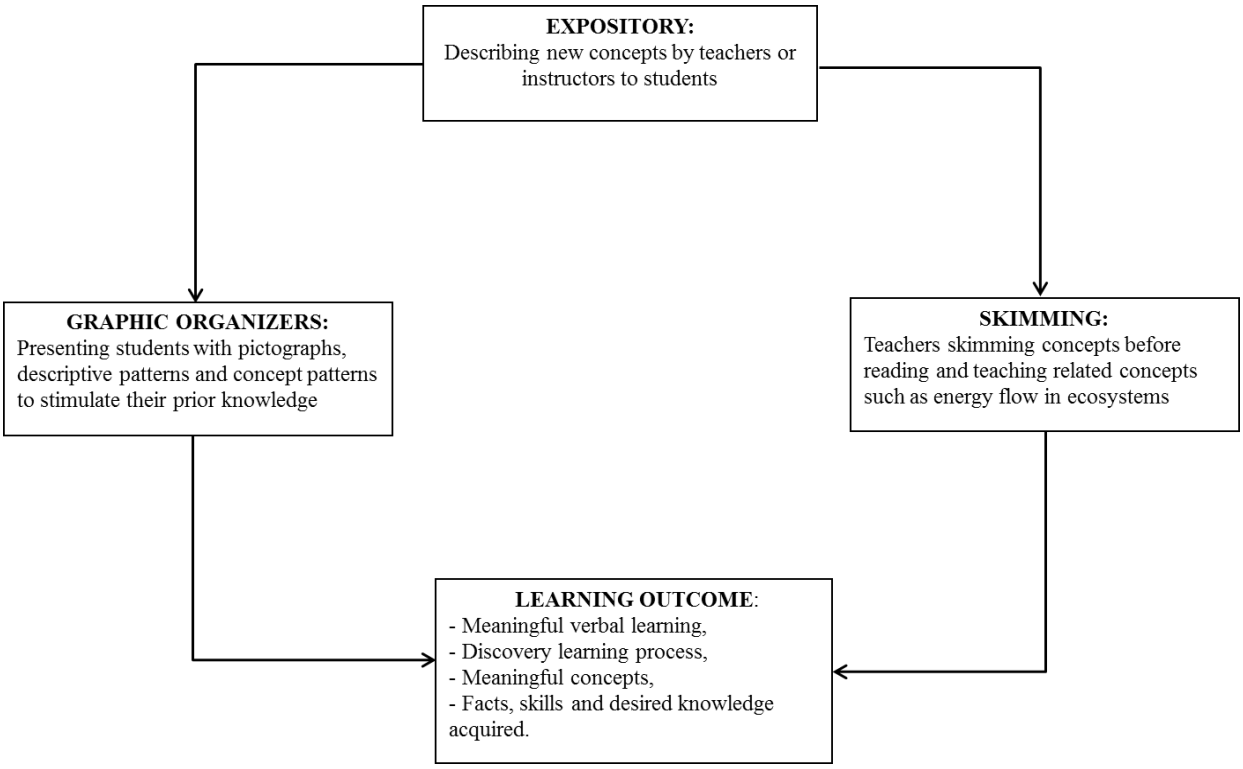


Figure.1 Theoretical Framework illustrating students' learning and conception in class
Author: Ausubel, 1963.

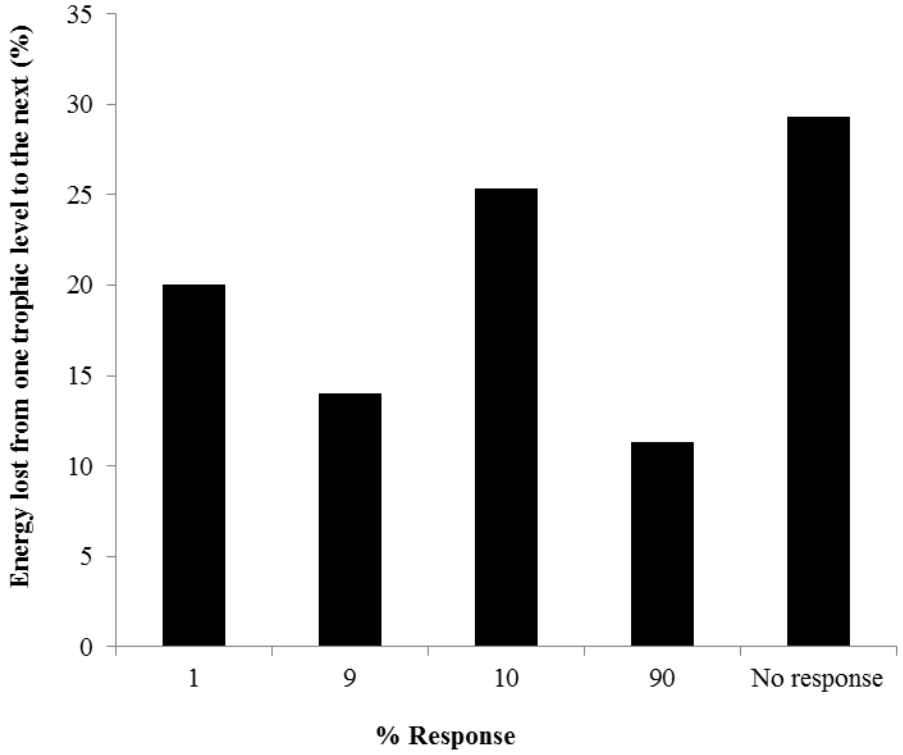


Figure 2: Students responses on energy flow from the sun through various trophic levels in joules and by percentages.(N=150)

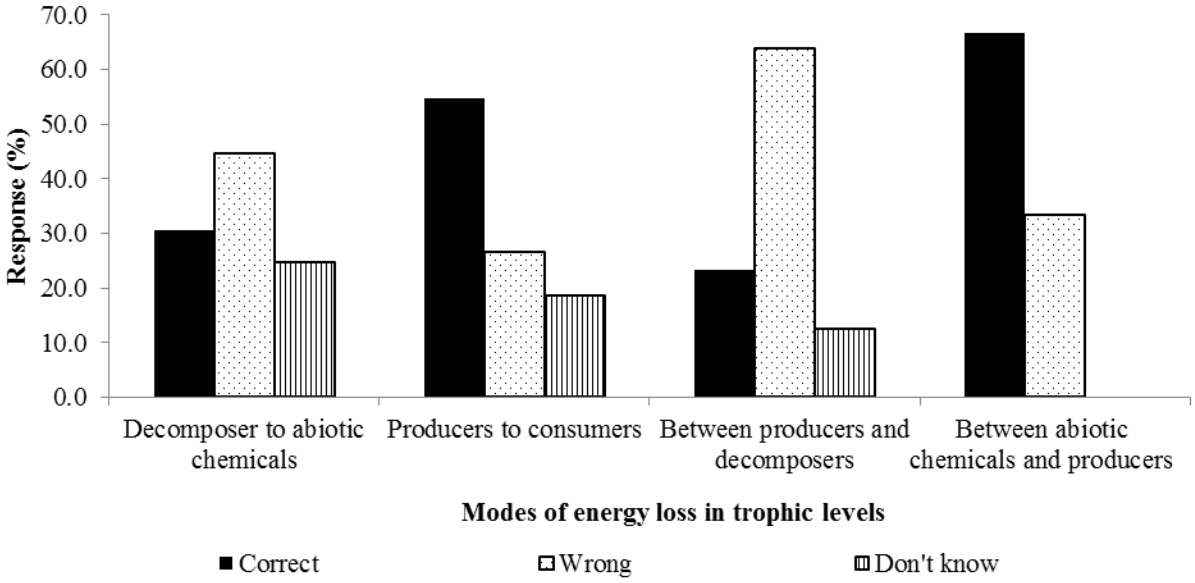


Figure 3: Students understanding of various modes of energy loss in ecosystems. (N=150)

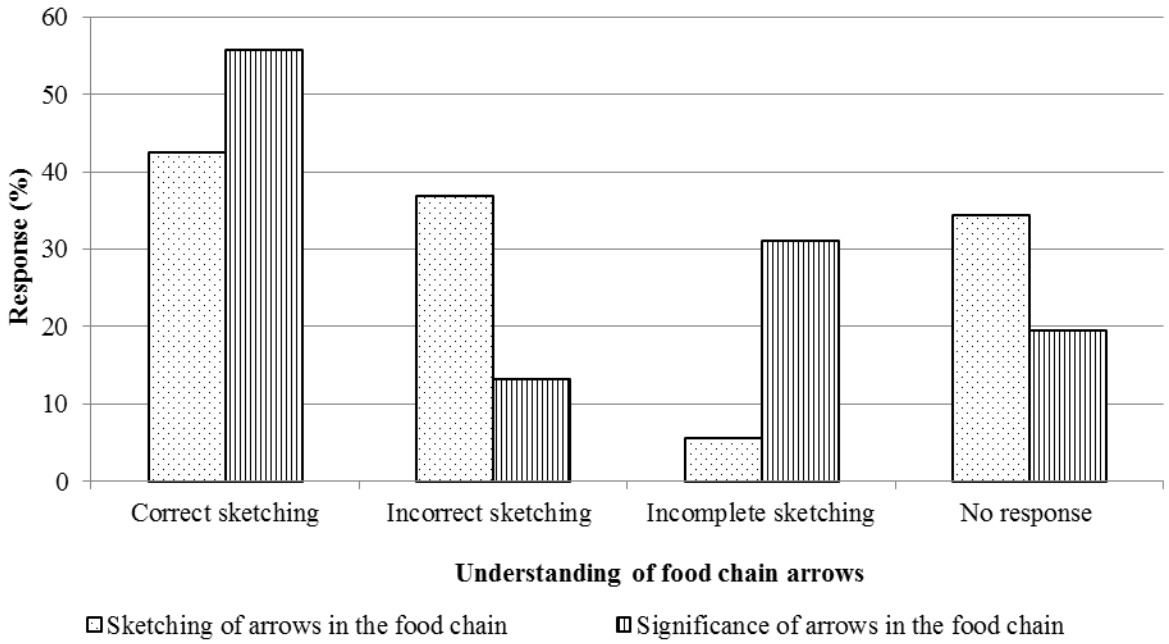


Figure4: Students understanding of food chain arrows and significance of arrows in the food chains in ecosystems. (n=150)

Tables

Table 1: Students' alternative understanding of energy flow in ecosystems

Statements about the understanding of energy flow in ecosystems	Response		
	% Agree	%Undecided	% Disagree
90 -100% energy is transferred to the next trophic level **(incorrect)**	29.6	16.8	53.6
9-10% energy is transferred to the next trophic level **(Correct)**	57.6	15.2	27.2
Plants synthesis their own food internally from gas and transferred in the ecosystems (**correct)**	58.4	12.8	28.8
Plants absorb food from the soil via the roots which is transferred to consumers **(incorrect)**	35.2	16.0	48.8
Plants manufacture food in the air which diffuses into pores in their leaves and stored **(incorrect)**	11.2	14.4	74.4
Organism higher in food web consume everything that is lower in the food web (**Incorrect)**	25.6	14.9	55.2
Organisms higher in the trophic levels have more energy than those lower in the trophic levels **(Incorrect)**	35.2	20.0	44.8
Organisms higher in the food chain accumulate all energy in the organisms lower in the food chains **(Incorrect)**	27.2	20.8	52.0
Energy is transferred from the predator to the prey **(correct)**	15.2	16.8	68.0
Solar energy is the main source of energy in the ecosystems (**Correct)**	74.4	17.6	8.0

n = 150

Additional Information
Study Questions

1.

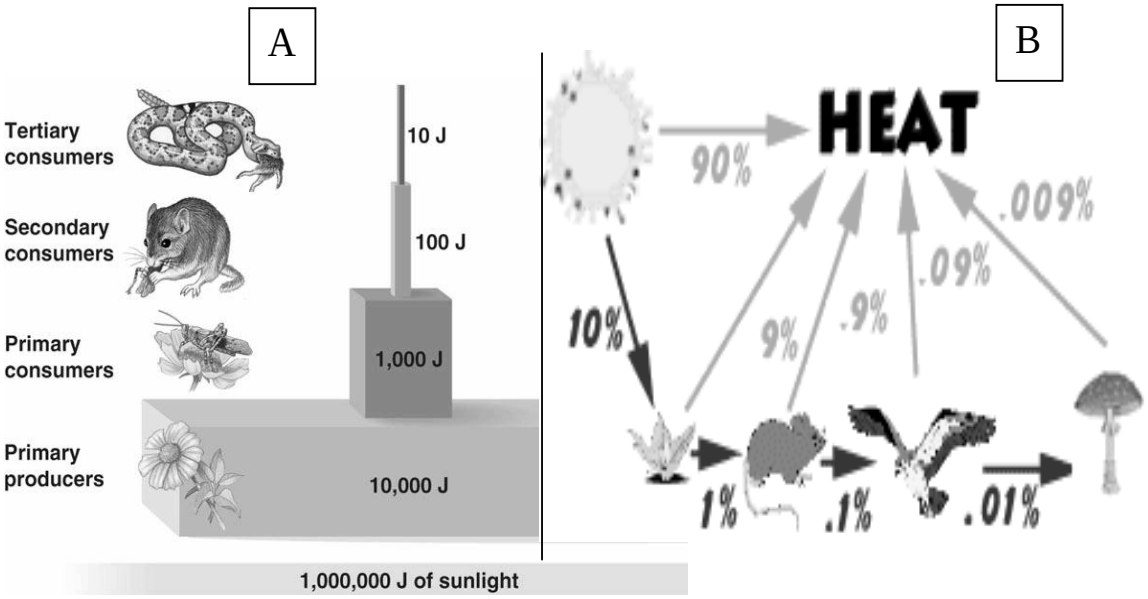


Figure: 5

2. i) Which statement below best explains the different percentages of energy flow in the ecosystems above?

a) Ten percent of energy is lost from one trophic to another trophic level

b) One percent of energy is lost from one trophic to another trophic level

c) Ninety percent of energy is lost from one trophic to another trophic level

d) Nine percent of energy is lost from one trophic to another trophic level

ii) Comment on how energy is reduced in different percentages as shown above?

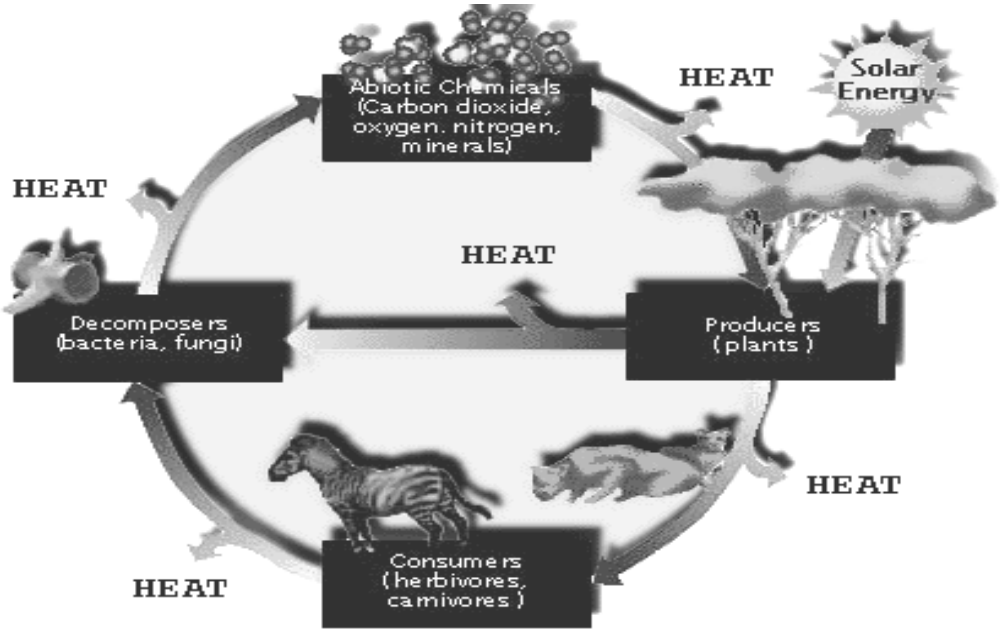
Figure, 6,

3.a) Use arrows to show energy flow in food chain below,

b) What is the significance of the arrows in the food chain? ----------



Sun steak meat Corn cow



Figure, 7,

4. a) State the processes of energy loss in ecosystems shown by phrases 'HEAT' from the options given below to complete the statements; PHOTOSYNTHESIS, RESPIRATION, DECOMPOSITION, FEEDING and DEATH.

i) From decomposers to abiotic chemicals----------
ii) From secondary consumers to decomposers----------
iii) From producers to consumers----------
iv) From producers to decomposers----------
v) From abiotic chemicals to producers----------

You are asked to express the extent to which you agree or disagree with opinion stated on a five point scale for which **5** indicates **strong agreement** and **1** indicates **strong disagreement**. Circle to the right of each statement which corresponds to your level of agreement. See below for an explanation of the rating.

5. ---------- STRONGLY AGREE [SA]
4. ---------- AGREE [A]
3. ---------- UNDECIDED [U]
2. ---------- DISAGREE [D]
1. ---------- STRONGLY DISAGREE [SD]

Table: 2

		SA	A	U	D	SD
1.	90-100% percentage energy is typically transferred to the next trophic in ecosystems.	5	4	3	2	1
2.	9-10% percentage energy is typically transferred to the next trophic in ecosystems.	5	4	3	2	1
3.	Plants make their own food internally mainlyfrom gas which is transferred in ecosystems.	5	4	3	2	1
4.	Plants absorb food from soil via the roots, which is transferred to consumers	5	4	3	2	1
5.	Plants manufacture food in the air, which diffuses into pores in their leaves and stored.	5	4	3	2	1
6.	Organisms higher in a food web consume everythingthat is lower on the food web.	5	4	3	2	1
7.	Organisms higher in trophics have more energy within them than those lower in the trophics.	5	4	3	2	1
8.	Organisms higher in trophics are more efficientin harvesting energy than those lower in the trophics.	5	4	3	2	1
9.	Organisms higher in a food chain accumulate all energy that is exists in the organisms that are lower in the food chain.	5	4	3	2	1
10.	Energy is transferred from the predator to the preyin ecosystems	5	4	3	2	1
11.	Solar energy is the main source of energy in ecosystems	5	4	3	2	1

KEY:

SA Strong Agree
A Agree
U Undecided
D Disagree
SD Strongly Disagree