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Author: Soyibo, Kola

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Some Sources of Students' Misconceptions in Biology: A Review

Kola Soyibo
Department of Educational Studies
University of the West Indies
Kingston 7, Jamaica

ABSTRACT

It is now widely acknowledged that students' misconceptions in science do impede their meaningful understanding of and good performance in the subject. A search in the literature reveals that textbooks, reference books, teachers, language, cultural beliefs and practices are some of the principal sources of high school students' misconceptions of many science concepts including biology. In this paper, some of the misconceptions students harbor in biology which originate from each of these sources are reviewed using cognate studies and documents. The implications of the conclusions from the review for biology education are addressed.

INTRODUCTION

Studies on students' understanding of biology concepts show that many students possess misconceptions of many concepts that are basic to a thorough knowledge of biology. Among the concepts investigated are the circulatory system (e.g. Arnaudin & Mintzes, 1985), diffusion (e.g. Westbrook & Marek, 1991), ecological concepts (e.g. Adeniyi, 1985), osmosis (Friedler, Amir & Tamir, 1987; Murray, 1983), photosynthesis (e.g. Wandersee, 1983), as well as students' misconceptions about photosynthesis and respiration (e.g. Soyibo, 1983; Stavy, Eisen & Yaakobi, 1987).

A search in the literature indicates that students' misconceptions in science may originate from many sources -2- including the following: (a) as a result of their interactions with the socio-physical world prior to formal

science instruction (e.g. Driver, Guesne & Tiberghien, 1985); (b) textbooks (Barrass, 1984; Cho, Kahle & Nordland, 1985; Soyibo, 1987, 1988); (c) reference books (e.g. Soyibo, in press); (d) teachers (Abimbola, 1984; Barrass, 1984); (e) language (Bell & Freyberg, 1985; Sutton, 1980, 1992; Wellington, 1983); and (f) cultural beliefs and practices (Champagne, 1986; George & Glasgow, 1988, 1989).

The purpose of this paper is to review some studies and related documents to demonstrate that the following are among the principal sources of high school students' misconceptions in biology: (1) textbooks, (2) reference books, (3) teachers, (4) language, and (5) cultural beliefs and practices. In this paper, the term misconceptions is defined as an idea or conception that is at variance with the accepted meaning in science (e.g. Nesher, 1987).

TEXTBOOKS

Three of the main sources of the common misconceptions students acquire from textbooks are misleading terms (e.g. Barrass, 1979,1984; Soyibo, 1985, 1988), specific erroneous statements (e.g. Barrass, 1984; Soyibo, in press) and analogy (e.g. Gilbert, 1989). Only the first two sources are considered in this section.

MISLEADING TERMS

Barrass (1979) identified 28 misleading terms in many introductory biology texts, syllabuses and examination papers. Soyibo (1987) listed 18 misleading terms he identified in five ordinary level biology texts used in Nigeria and elsewhere. Soyibo (1985, 1988, 1990, in press) has shown that such misleading terms do contribute to the common misconceptions that high school biology students and teachers harbor on the subject.

Table 1 displays some of the misleading terms identified by Barrass (1979) and Soyibo (1987) which are still presented in some relatively recently published high school biology texts used in the Anglophone Caribbean, West Africa and elsewhere. The asterisked alternatives in the table are those suggested

in some biology textbooks, while the others are those originally suggested by Barrass (1979, 1984). The texts coded as 4 and 8 are written for advanced level students, while the other seven are for ordinary level students.

Table 1
Some Misleading Terms in Biology Texts and Suggested Alternatives

Misleading terms	Texts' codes	Suggested Alternatives
cellular respiration	2,3,4,5,8	respiration
cold blooded	3,6,7,8	poikilothermic*
external respiration	2,9	gas exchange*
internal respiration	2,3,9	respiration
respiratory organs	2,3,5,9	gas exchange organs*
respiratory surface	1,2,4,5,6,7,9	gas exchange membrane
respiratory system	1,5,6,7,9	gas exchange system
semi-permeable		selectively permeable
membrane	1,2,5,6,7,8,9	membrane*
tissue respiration	2,3,5,9	respiration
warm blooded	3,6,7,8	homoiothermic*

Key

1. Chinnery, L., Glasgow, J., Jones, M., & Jones, Q. (1992).
2. Green,N.P.O., Stout, G.W., Taylor, D.J, & Soper, R. (1990).
3. Mackean, D.G., (1984).
4. Mader, S.S. (1987).
5. Ndu, F.O.C., Asun, P.,& Aina, J.O. (1988,1990).
6. Okeke, E.A. C. et al. (1990).
7. Roberts, M.B.V., & Mitchelmore, J. (1985).
8. Soper, R., Smith, S.T., & King, W.K. (1991).
9. Stone, R.H., & Cozens, A.B. (1985).

Most of the misleading terms in the nine texts listed in Table 1 are on respiration. According to Barrass (1979), once students have been told that respiration occurs only in living cells (and syncytia), the terms cellular respiration, internal respiration and tissue respiration are unnecessary. On this count, the term external respiration is equally

misleading. Although Green et al. (1990) and Stone & Cozens (1985) use this term to mean gas exchange in all organisms, Soyibo (1985, in press) reported that many eleventh grade students interpreted the term to mean breathing in humans/animals (Table 2 and 4). Whereas Mackean (1984) and Stone & Cozens (1985) employed the term internal/tissue respiration to mean the release of energy in all living cells, many Nigerian and Jamaican eleventh graders, according to Soyibo (1985, in press) interpreted the term to denote respiration in human/animal tissues (Table 4). On the other hand, Mader (1987), pp.475 -484), under the caption "Respiration and excretion", deals only with gas exchange in animals. She therefore gives the text's readers the erroneous impression that respiration is a synonym for gas exchange and that only animals exchange gases.

Mackean (1984), Okeke et al. (1990), Roberts & Mitchelmore (1985) and Soper et al. (1991) use the obsolete, misleading term cold blooded while referring to the variable body temperatures of some ectotherms (e.g. amphibians and reptiles) relative to the equally variable external temperatures of their surroundings. They also use the term warm blooded to describe the relatively
constant body temperatures of birds and mammals (endotherms). These two terms are misleading because they can make many students to believe that the named organisms always have "cold" and "warm" blood respectively. Respiratory organs (e.g. gills, lungs), are referred to as the organs used for gas exchange during aerobic respiration by Green et al. (1990), Mackean (1984), Ndu et al. (1990) and Stone & Cozens (1985). But as Soyibo (1985, in press) reported, the term misled many high school students to regard it as the organ used for respiration (Table 4).

With the exception of Mackean (1984) and Soper et al. (1991), all the other seven texts use the term respiratory surface (e.g. alveoli, skin of earthworm and toad/frog)

instead of gas exchange membrane. For example, Chinnery, et al. (1992,p.63) define a respiratory surface as "the part of the organism through which oxygen enters the body." This statement is a misconception because it does not specify the medium in which oxygen enters as well as the fact that oxygen usually enters terrestrial aerobes' bodies along with other atmospheric gases (e.g. nitrogen, carbon dioxide) during respiration. Moreover, the term can mislead many students to denotivately perceive a respiratory surface as the "surface" in an organism where respiration occurs.

The texts by Chinnery, et al. (1992), Ndu et al. (1990), Okeke et al. (1990), Roberts & Mitchelmore (1985) and Stone & Cozens (1985) employ the term respiratory system while discussing the breathing mechanism in humans. This situation is capable of making students acquire the misconception that breathing means respiration as reported by some researchers (e.g. Soyibo, 1983, 1985, 1988, in press; Stavy, Eisen & Yaakobi, 1987).

The term semi-permeable membrane, used in respect of osmosis in seven of the texts, except Mackean (1984) and Mader (1987), is misleading. This is because students can interpret the term to mean either partly permeable or partially impermeable. But in reality, the membrane only allows water molecules and not solute molecules to pass through it. Hence, it is selectively or differentially permeable. Indeed, this author suspects that the increased confusion that Murray (1983) reported some American university students had, over the properties of semi-permeable membranes after instruction on osmosis, might be due in part, to the use of this misleading term.

Soyibo (1985, in press) concluded that the misconceptions that many Nigerian and Jamaican eleventh graders had on the misleading terms (external respiration,

tissue/internal respiration and respiratory organ) discussed above, could partly be attributed to their presence in some biology texts like those in Table 1. In Table 4 are the misconceptions held by the students on the misleading terms and other biological terms.

TEXTS' MISCONCEPTIONS

1. Respiratory surfaces must always be moist

As Barrass (1984) reported, both biology syllabuses and textbooks encourage teachers of biology to perpetuate the conception that oxygen must be in solution before it can diffuse into an organism's body. For example, the Caribbean Examinations Council (CXC) secondary school certificate biology syllabus (1992) and the West African Examinations Council (WAEC) senior secondary certificate examination (Nigeria) biology syllabus (1991-9993), demand a study of the characteristics of a respiratory surface - i.e surface area, moistness, thinness and blood supply. The belief that such surfaces must be moist is stated as a fact in most textbooks for introductory and advanced courses examined by Barrass (1984) as well as those analyzed in this paper. Specifically, seven of the nine texts listed in Table 1 - except those by Makean (1984) and Soper et al. (1991) - express this view. For instance, Chinnery et al. (1992), p. 64) state that respiratory surfaces must be kept moist as oxygen will not diffuse across them unless it dissolves in water. In a textbook for advanced level courses, Mader (1987), p. 475), states that animals' gas exchange regions/areas must be moist for effective diffusion.

As discussed earlier, the term respiratory surface is misleading. As Barrass (1984) correctly noted, a respiratory surface is only indirectly concerned with aerobic respiration in animals; in plants, it is concerned indirectly with photosynthesis and respiration; in all organisms, it is concerned with excretion; and a surface cannot have a thickness. Hence, the term gas exchange membrane should be

preferred by biologists as Barrass argued.

The gas exchange membrane, through which the exchange of gases occurs between a living cell and its environment, is always the plasmalemma. In animals without a blood circulatory system, the diffusion distance between the gas exchange membrane and body cells is always short (Barrass, 1984).

Not all gas exchange membranes have a blood supply. Many organisms have no blood e.g. protists, cnidarians and platyhelminthes. In insects, oxygen and carbon dioxide are not transported by the blood but diffuse rapidly through air-filled tubes directly to and from the tissues (Barrass, 1984).

As Barrass (1984) further emphasized, the gas exchange membrane of most aquatic organisms are moist
because they are permeable to water, oxygen and carbon dioxide. The water on the membrane is not a desirable feature but an unavoidable aspect of gas exchange. The water does not help diffusion while, in fact, oxygen and carbon dioxide diffuse more rapidly through air than through water.

2. Respiration means breathing

Some of the recently published biology texts in Table 1 and reference books (e.g. Abercrombie et al., 1980, see Table 2) still define respiration to mean breathing - the everyday language meaning of the former. For example, Roberts & Mitchelmore (1985, p.70) write, "When living things breathe (respire), they use up oxygen and give out carbon dioxide." This statement is a misconception for a number of reasons including the following: First, not all living things breathe or use up oxygen for respiration. Second, many aerobes such as multicellular plants and many insects do not "breathe" the way most vertebrates do but all aerobes exchange gases. That is, they take in air containing a lot

of oxygen, use the oxygen to oxidize food (e.g. glucose) and release a lot of chemical energy with the aid of enzymes in living cells' mitochondria, while the carbon dioxide produced is sent out along with other gases. In anaerobic respiration, oxygen is not used up, but energy is also released while carbon dioxide (e.g. in yeast, a fungus) or a biogas containing methane (in bacterial fermentation) can be produced as a by-product. Succinctly, respiration can be defined as the process by which energy is released from food (in form of simple sugar) in the mitochondria of living cells with the aid of enzymes in the absence on presence of oxygen.

Soyibo (1985, in press) attributed many Nigerian and Jamaican eleventh grade students' misconception that respiration means breathing in and out to the fact that some biology texts like Roberts & Mitchelmore (1985) mentioned earlier, as well as some biology and English dictionaries (Tables 2 and 3), specifically advertise this misconception. Haslam & Treagust (1987) reported that many Australian 13 -17 year old students (n=441), also regarded respiration and breathing to be synonymous.

3. Egestion is excretion

Many students regard excretion (the removal of metabolic waste products) and egestion (voiding faeces/excreta) as synonyms. Barrass (1984) suggested that this misconception is probably the result of the difference between the everyday use of the word excretion and excrement and the precise use of the scientific term excretion in biology. However, some biology texts seem to be the real sources of this misconception. For instance, Stone & Cozens (1981, p. 8.) define excretion as "the elimination of waste substances from our body in the form of excreta." This definition also gives the erroneous impression that excretion occurs only in animals, particularly humans, whereas it occurs in all living things.

4. Digestion is a characteristic of animals

Many introductory texts gives students the wrong impression that digestion occurs only in animals in their definition of the term. For example. Chinnery et al. (1992, p. 314) define digestion as "the process by which animals break down complex food substances into simpler ones which they can use." Likewise, Roberts & Mitchelmore (1985, p. 7) give the erroneous information that digestion occurs only in animals especially in "man's gut." But students for whom the texts are written are required to know that besides the extracellular
digestion in fungi (e.g. Mucor and Rhizopus), other plants (e.g. embrophyta) digest their food enzymatically like animals prior to its translocation to various parts of their bodies. This misconception - which was held by many Nigerian and Jamaican eleventh graders, according to Soyibo (1985, in press) - (see Table 4), was likely to have originated from some biology texts like those cited above.

REFERENCE BOOKS

Two types of reference books examined for possible sources of students' misconceptions are three dictionaries of biology and four English language dictionaries. Tables 2 and 3 display specimen misconceptions contained in some of the two sets of dictionaries in respect of some physiological processes.

Table 2
Specimen Misconceptions in Some Dictionaries of Biology

Excretion getting rid of products of metabolism. In animals ... organs mainly concerned being the kidneys of vertebrates (Abercrombie, Hickman & Johnson, 1980).

Digestion breakdown of complex foodstuffs by enzymes into simpler compounds... In many animals, it is extracellular (e.g. vertebrates), in others, it is intracellular e.g. coelenterates). (Abercrombie et al.)

Growth increase in size . In botany ... increase in plant size (Abercrombie et al.).

Osmoregulation in animals, regulation of the pressure in the body by controlling the amount of water and/or salts (Holmes, 1979).

Respiration (1) breathing e.g. pumping air in and out of lung or water over gills (2) taking in oxygen from the environment and giving off carbon dioxide (1) and (2) are sometimes referred to as external respiration in contrast to (3) internal, tissue or cell respiration.. (Abercrombie et al.).

Respiratory organ an organ/structure which functions in gaseous exchange as the integument, gills, trachea.. alveolar lungs of mammals (Steen, 1971)

Table 2 signals that some dictionaries of biology, like some biology texts mentioned earlier, contain misleading terms on respiration which can breed misconceptions in students and their teachers. All the six physiological processes in the table, except digestion, occurs in most living plants and

animals. For instance, some organisms (e.g. ectoparasite and endoparasite do not need to digest their food while gas exchange is a feature of aerobes. Because the dictionaries failed to generalize their definitions on them, their definitions constitute misconceptions. The definition of respiration in Abercrombie et al. (1980), typifies the everyday language meaning of the term given in some dictionaries of biology and, hence, is biologically a misconception.

Table 3

Specimen Misconceptions on Biology Concepts in Some English Dictionaries

Excretion the act of producing excreta (Summers, 1987).

Digestion the dissolving of food in the stomach (Kirkpatrick, 1983).

Fruit the usually sweet and fleshy edible product of a plant/tree containing seeds (Hawkins & Allen, 1991; Summers, 1987).

Growth increase in size or value (Hawkins & Allen, 1991; Skyes, 1976).

Respiration breathing (Kirkpatrick, 1983; Summers, 1987). breathing; simple inspiration and expiration; plants' absorption of oxygen and emission of carbon dioxide (Sykes, 1976).

As expected, the English language dictionaries' definitions of the biology terms in Table 3 are their everyday meanings. But biologically, the definitions contain obvious misconceptions (some of which have been discussed earlier). These misconceptions are similar to those held by many Nigerian and Jamaican eleventh graders reported by Soyibo (1985, in press) (see Table 4). It therefore appears that the specific biology misconceptions in biology texts discussed in the preceding section are likely to have originated from the tendency of some authors of biology texts to give everyday meanings to biological terms (e.g growth, excretion, digestion and respiration) which are also used in everyday discourse instead of giving their strict biological meanings. Barrass (1984) pointed out that scientists first

used a term (e.g. respiration) to convey its commonly accepted meaning (breathing) but later used the same term for a different process which occurs in all living cells (not just those organisms that breathe). Therefore, they felt it was necessary to distinguish between external, internal,tissue or cellular respiration. These terms,as earlier discussed, are misleading and should be expunged from biology texts and
dictionaries to avoid confusing students. A fruit may contain seeds, in seed, or no seed.

TEACHERS

Barrass (1984) reviewed 15 biology misconceptions commonly held by UK students who had passed their ordinary level examinations and identified 12 of them which he claimed were perpetuated by teachers of biology as well as the authors of some school textbooks. Science teachers and students rely heavily on science texts for most of their teaching and learning respectively (Stinner, 1992). Therefore, many of the misconceptions that biology teachers harbor on biology are likely to have originated partly from the biology texts and reference books they consult for their teaching and partly from the misconceptions they too had acquired as students of biology. It seems to be an obvious corollary that many misconceptions teachers of biology hold are likely to be transmitted to their students. The findings from the investigations of Soyibo (1985, 1988, 1990, in press) on some students' and teachers' misconceptions on some biological terms seem to confirm this assertion (Table 4 and 5).

Soyibo (1985, 1988) instructed 93 Nigerian eleventh graders and 84 first and final year biology -education (B.Sc.Ed) Nigerian undergraduates respectively, to explain the meanings of 20 biology terms and to give two examples where necessary. Soyibo (1990) requested 35 Nigerian secondary school practising biology teachers to explain the

meanings of 16 biological terms similar to those he had administered to the first two sets of Nigerian subjects. Soyibo (in press) also administered the instrument he administered in 1985 and 1988 to 124 Jamaican eleventh graders. He discovered that the misconceptions held on the 20 terms by many Nigerian and Jamaican eleventh graders were virtually the same and
were also similar to those held by the Nigerian biology student-teachers as well as those of the practising biology teachers. Tables 4 and 5 show some of the common misconceptions held by the students and teachers respectively.

Table 4

Common Biology Misconcepts Held By Nigerian and Jamaican Eleventh Graders

Diffusion movement of gas/liquid from an area of high to an area of low concentration.

Excretion removal of waste from the body e.g. faeces.

External respiration the breathing in and out of air e.g. in man.

Fertilization the fusion of sperms and eggs in man.

Osmoregulation maintenance of a constant amount of water in the blood.

Osmosis movement of a weak solution into a strong solution through a semi-permeable membrane.

Reproduction process of giving birth to young ones alive e.g. humans.

Respiration the breathing in of oxygen and the breathing out of carbon dioxide in man.

Respiratory organ organ used for respiration e.g. gills, lungs.

Seed an ungerminated plant e.g. maize

Tissue respiration respiration that occurs in human/animals tissues.

Table 5

Common Misconceptions Held by Some Nigerian Biology Teachers

Diffusion movement of gas/liquid molecules from a region of high to a region of low concentration

Excretion removal of nitrogenous waste products from organisms' bodies via organs like the skin and lungs.

External respiration the breathing in of oxygen and the breathing out of carbon dioxide.

Fertilization the process by which male sperm and female ovum fuse e.g. in humans.

Osmoregulation the process by which an animal's water content is kept constant.

Osmosis movement of a solvent from low concentration to high concentration through a semi-permeable membrane.

Reproduction process by which organisms give birth to young ones.

Respiration process by which oxygen taken in breaks down digested food (sugars) to release energy consisting of

external and tissue respiration.

Respiratory organ an organ used for respiration e.g. gills, lungs.

Seed a developed ovule e.g. maize grain.

Tissue respiration process by which oxygen breathed in is used in body tissue to oxidize food and release energy, water and carbon dioxide.

Table 4 suggests that the misconceptions held by Nigerian and Jamaican eleventh graders on the same biological terms seem to have originated, in part, from their biology teachers. Tables 4 and 5 signal that both the students and teachers did not recognize the randomness and even distribution of particles typical of diffusion and the fact that the particles of solids also diffuse. While the teachers were aware that it is water that moves during osmosis, they did not recognize that osmosis is a modified form of diffusion. This is because, in the former, water molecules move from an area of high water concentration (weak solution) to an areas of low water concentration (strong solution) via a selectively permeable membrane - i.e one that allows water but not the solute particles to pass through it from either solutions. As earlier mentioned, the term semi-permeable membrane is misleading. The students' and teachers' misconceptions on diffusion and osmosis are similar to those of students reported in some studies (e.g. Westbrook & Marek, 1991, on diffusion and Friedler, Amir, & Tamir, 1987 on osmosis.

The students' and teachers' misconceptions on physiological processes (e.g. excretion, fertilization, reproduction and respiration, see Tables 4 and 5), as pointed

out earlier, could be attributed partly to the tendency of some authors of biology texts and reference books (e.g. biology dictionaries) to define such terms almost exclusively with reference to animals particularly humans. This practice is likely to be due to the fact
that these physiological terms are also used in everyday language. But, biologically, the process occurs in all living organisms. The misconceptions on respiration were partly due to the use of misleading terms (e.g. external respiration, respiratory organ, tissue respiration) in some biology texts and reference books as discussed earlier. Biologically, a maize grain is a one-seeded fruit (caryopsis) and not a seed as it was misconceived by the students and teachers (Tables 4 and 5). In sum, students and teachers' misconceptions on respiration and photosynthesis (Tables 4 and 5) confirm the findings of some authors (e.g. Haslam & Treagust, 1987; Soyibo, 1983).

LANGUAGE

Considerable attention has been focused on the role of language in the construction and maintenance of misconceptions in science education research. Some researchers (e.g. Ashlock, 1987) have focused on defining and labelling concepts relative to the structure of a discipline. Others (e.g. Solomon, 1983) dealt with the description of the relationships between the use of scientific terms (e.g. energy, force, heat) in everyday life and the precise definitions of these terms. Sutton (1980, 1992) distinguished between denotative meanings in science (rigorous definitions) from connotative meanings in everyday experience (extra associations and connections to their experiences).

Wellington (1983) proposed a taxonomy of denotative scientific words with four categories: naming words (e.g. saliva, meniscus), process words (e.g. evaporation,

photosynthesis) concept words (e.g. energy, fruit, salt) and mathematical words. According to him, concept words which have both scientific and everyday meanings (e.g. energy, force, heat, power, pressure, work) constitute the main sources of students difficulties and misconceptions in science. Examples of biological terms which have everyday meanings displayed in Table 4 are digestion, excretion, fertilization, and respiration. As underlined earlier, a possible source of students' and teachers' misconceptions (Tables 4 and 5) is their tendency to give the everyday meanings of such terms instead of their precise biological meanings. This is a practice that is evident in some biology dictionaries (Table 2) and texts as well as English dictionaries (Table 3) discussed earlier. The tendency of many students and teachers to ascribe everyday meanings to biological terms is supported by Bell & Freyberg's (1985) explanation that because much of cultural meanings of words are expressed in verbal communication, it is the metaphoric everyday rather than the scientific meanings of a word that is in common usage that pupils will adopt. Another possible reason for this tendency is that historically, many scientific terms were generated from words used in everyday discourse (Sutton, 1992).

CULTURAL BELIEFS

Some researchers have implicated cultural beliefs as sources of interference with science learning (e.g. Champagne, 1986; Hewson, 1985). Hewson reported that the cultural and cognitive beliefs of the natives of Sotho in Southern Africa about heat conflicted with their scientific conceptions of the concept.

George & Glasgow (1988) analyzed the main features of the street science beliefs of 15- year-old Jamaican, Trinidad and Tobago students that are likely to interfere with their meaningful learning of conventional science. Street science

is defined as "those social customs and beliefs that deal with the same content areas that are dealt with in conventional science but which sometimes offer different explanations to those offered in conventional science". Again, George & Glasgow (1989) identified some of the cultural beliefs which are likely to enhance or interfere with students' learning of the CXC secondary science syllabuses. They concluded that it might be difficult to formulate suitable strategies for dealing with the mix of street science and conventional school science because the majority of Caribbean teachers show a commitment to the two systems.

Wandersee (1983) opined that cultural/societal practices encourage misconceptions about how plants live. The examples he gave include: (a) garden shops that sell fertilizers labelled as "plant food" and "weed food"; (b) florists talk about "feeding" their green house crops; (c) mothers who tell their children to "give the plant a drink". Two of the 31 misconceptions his subjects held about photosynthesis which seem to be rooted in such cultural beliefs and practices are: The soil is the plant's food (2) People put food (fertilizer) in the soil for plants to eat.

CONCLUSIONS AND IMPLICATIONS

Misleading terms and specific erroneous statements in many biology texts are two of the major sources of high school students' misconceptions in biology. Therefore, authors of biology dictionaries and texts need to ensure that such terms and statements are not perpetuated in subsequent editions of their publication. This may help in blocking two of the main sources of students' misconceptions in the subject.

The tendency of some authors of biology dictionaries and

textbooks to give everyday language meanings to biological terms that are also used in everyday language is a source of many students' and teachers' misconceptions in biology. Hence, only the stringent biological meanings of words that are used in biology and also in everyday discourse (e.g. excretion, digestion, respiration) should be given in biology dictionaries and textbooks. Teachers and authors of biology texts and dictionaries need to recognize the fact that the ability to generalize (recognize "patterns") is one of the favoured touchstones of sound or meaningful scientific/biological understandings. Consequently, they should always give generalized meanings of physiological terms (e.g. growth, osmoregulation) that apply to all organisms instead of relating their meanings to animals/humans in an attempt to simplify the meanings of such terms.

Many high school teachers of biology are the sources of many students' misconceptions on the subject. It is likely that if the misconceptions in biology texts and reference books are minimized, the misconceptions that many teachers unwittingly impart to their students from these sources would be reduced. Biology teachers need to sensitize their students to the fact that most English language dictionaries tend to give the everyday meanings of biological and other scientific terms and that these are scientifically incorrect , and hence, unacceptable. It is necessary to assist biology teachers to recognize some of their own misconceptions which they need to abandon. This can be done by using the conceptual change teaching strategies proposed by some researchers (e.g. Champagne, Gunstone & Klopfer, 1983; Smith, Blakeslee & Anderson, 1983). This can be done during the biology methodology courses of prospective high school biology teachers and workshops/seminars in respect of practising biology teachers. Through these media, teachers of biology should be alerted to specific instances of how

their students' cultural beliefs and practices could be sources of their misconceptions of biology. The teachers also need to be exposed to the constructivist approaches to science teaching and learning which have been shown to be effective in effecting conceptual change in their students while assisting them to overcome their misconceptions (e.g. Driver & Oldham, 1986). If some of the sources of students' misconceptions in biology reviewed above can be effectively blocked or appropriately dealt with,
the misconceptions they harbor are likely to be lessened and their understanding of the subject is likely to improve.

REFERENCES

Abercrombie, M., Hickman, C. J., & Johnson, M. L. (1980). Penguin dictionary of biology (7th ed). Harmondsworth: Penguin.

Abimbola, I .O. (1984). A study to describe and explain the alternative conceptions related to human respiration held by selected Nigerian form four students. Doctoral Thesis. Dissertation Abstracts International, 45(05) 1357 -A, No. DA8414218.

Adeniyi. E. O. (1985). Misconceptions of selected ecological concepts held by some Nigerian students. Journal of Biological Education, 19, 311-346.

Arnaudin, M. W., & Mintzes, J. J. (1985). Students' alternative conceptions of the human circulatory system: A cross-age study. Science Education, 69(5), 721-733.

Ashlock, R. (1987). Use of informal language when introducing concepts. Focus on Learning Problems in Mathematics, 9(3), 31-37.

Barrass, R. (1979). Vocabulary for introductory courses in

biology: Necessary, unnecessary and misleading terms. Journal of Biological Education, 13(3), 179-181.

Barrass, R. (1984). Some misconceptions and misunderstandings perpetuated by teachers and textbooks of biology. Journal of Biological Education, 18(3), 201-206.

Bell, B. & Freyberg, P. (1985). Language in the science classroom. In R. Osborne & P. Freyberg (Eds.). Learning in science. Auckland: Heinemann.

Caribbean Examinations Council (1992). Secondary school certificate biology syllabus. St. Michael: CXC.

Champagne, A. B. (1986). Children ethno-science: An instructional perspective. J. Gallagher & G. Dawson (Eds.), Science education and cultural environments in the Americas. Washington, D.C.: National Science Teachers Association.

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1985)_. Effecting changes in cognitive structures among physics students. In L. H. T. West & A. L. Pines (Eds.), Cognitive structure and conceptual change. Orlando, FL: Academic.

Chinnery, L., Glasgow, J., Jones, M., & Jones, G. (1992). CXC biology. Cambridge: Cambridge University Press.

Cho, H. Kahle, J. B., & Nordland, F. H. (1985). An investigation of high school biology textbooks as sources of misconceptions and difficulties in genetics and some suggestions for teaching genetics. Science Education, 69(5), 707-719.

Driver, R., Guesne, E., & Tiberghein, A. (Eds.) (1985). Children's ideas in science. Milton Keynes: Open University Press.

Driver, R., & Oldham, V.(1986). A constructivist approach to curriculum development in science. Studies in Science Education, 13, 105-122.

Friedler, Y., Amir, R., & Tamir, P. (1987). High school students' difficulties in understanding osmosis. International Journal of Science Education, 9(5), 541-551.

George, J., & Glasgow, J. (1988). Street science and conventional science in the West Indies. Studies in Science Education, 15, 109-118.

George, J., & Glasgow, J. (1989). Some cultural implications of teaching towards common syllabi in science: A case study from the Caribbean. School Science Review, 71(254), 115-123

Gilbert, S. W. (1988). An evaluation of the use of analogy, simile, and metaphor in science texts. Journal of Research in Science Teaching, 26(4), 315-327.

Green, N. P. O., Stout, G. W., Taylor, D. J. & Soper, R. (1990). Biological science 1: Organisms, energy and environment. Cambridge: Cambridge University Press.

Green, N. P. O., Stout, G. W., Taylor, D. J. & Soper, R. (1990). Biological science 2: Systems, maintenance and change. Cambridge: Cambridge University Press.

Haslam, F., & Treagust, D. F. (1987). Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument. Journal of Biological Education, 21(3), 203-211.

Hawkins. J. M., & Allen, R. (Eds.) (1991). The Oxford encyclopedic English dictionary. Oxford: Clarendon Press.

Hewson, M. G. (1985). The role of intellectual environment in the origin of conceptions: An exploratory study. In L. West & A. Pines (Eds.), Cognitive structure and conceptual change (pp. 153-162). New York: Academic Press.

Holmes, S. (1979). Henderson's dictionary of biological terms (9th ed.) London: Longman.

Kirkpatrick, E. M. (Ed.) (1983). Chambers 20th century dictionary. Edinburgh: W&R Chambers Ltd.

Mackean, D. G. (1984). Introduction to biology (3rd tropical ed.) London: John Murray.

Mader, S. S. (1987). Biology: Evolution, diversity and the environment (2nd ed.) Dubuque, Iowa: W.C. Brown Publishers.

Murray, D. L. (1983). Misconceptions of osmosis. In H. Helm & J. D. Novak (Eds.), Proceedings of the international seminar: Misconceptions in science and mathematics (pp. 428-433). Ithaca: Cornell University, USA.

Nesher, P. (1987). Towards an instructional theory: The role of students' misconceptions. For the Learning of Mathematics, 7(3), 33-40

Ndu, F. O. C, Asun, P., & Aina, J. O. (1988). Senior secondary biology 1. Lagos: Longman Nigeria Ltd.

Ndu, F. O. C., Asun. P. & Aina, J. O. (1990). Senior secondary biology 2. Lagos: Longman Nigeria Ltd.

Okeke, E. A. C. Oyetola, O. A., Owolabi, J. B., Udofia, P. P., Abubakar, M. A., & Ayabam, C. W. (1990). Science Teachers Association: Biology for senior secondary schools. Ibadan:

Heinemann.

Roberts, M. B. V. & Mitchelmore, J. (1985). Biology for CXC. Surrey: Thomas Nelson.

Smith, E. L., Blakeslee, T. D., & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. Journal of Research in Science Teaching, 30(2), 111-126.

Solomon, J. (1983). Messy, contradictory and obstinately persistent: A study of children's out-of-school ideas about energy. School Science Review, 65(231), 225-229.

Soper, R., Smith, S. T., & King, W. K. (1990). Caribbean biology for CXC (2nd ed.). London: Macmillan

Soyibo, K. (1983). Selected science misconceptions among some Nigerian school certificate students. In H. Helm & J. D. Novak (Eds.), Proceedings of the international seminar: Misconceptions in science and mathematics (pp. 425-427). Ithaca: Cornell University, USA.

Soyibo, K, (1985). Nigerian school certificate candidates' knowledge of and misconceptions on some basic biology concepts. 26th Annual conference proceedings of Science Teachers Association of Nigeria (pp. 127-130). Sokoto, Nigeria.

Soyibo, K. (1987). An analysis of the diagrams and terms used in some O -level biology textbooks. Journal of Research in Curriculum, 2, 31-38

Soyibo, K. (1988). A comparison of first and final year undergraduate student-teachers' knowledge and misconceptions on selected biology concepts. Journal of Research in

Curriculum, 6(1), 13-20.

Soyibo, K. (1990). An analysis of some biology teachers' knowledge of and misconceptions on selected biology concepts. West African Examinations Council Seminar Papers, 8, 61-72. Lagos: WAEC.

Soyibo, K. (in press) Effects of gender, school location, socio-cultural beliefs and anxiety levels on Jamaican eleventh grade students' knowledge and misconceptions of some biological terms. Science Education.

Stavy, R., Eisen, Y., & Yaakobi, D. (1987). How students aged 13-15 understand photosynthesis. International Journal of Science Education, 9(1), 105-115.

Steen, E. B. (1971). Dictionary of biology. New York: Barnes & Noble Publishers.

Stinner, A. (1992). Science textbooks and science teaching: From logic to evidence. Science Education,
76(1), 1-16.

Stone, R. H. & Cozens, A. B. (1985). New biology for West African schools (2nd ed.) London: Longman.

Summers, D. (Ed.) (1987). Longman dictionary of contemporary English. Essex: Longman.

Sutton, C. (1990). Science, language and meaning. School Science Review, 62, 47-56

Sutton, C. (1992). Words, science and learning. Buckingham: Open University Press.

Sykes, I. B. (Ed.) (1976). The concise Oxford dictionary (6th ed.). Oxford University Press

Wandersee, J. H. (1983). Student's misconceptions about photosynthesis. In H. Helm & J. D. Novak (Eds.), Proceedings of the international seminar: Misconceptions in science and mathematics (pp. 441-446). Ithaca: Cornell University, USA.

Wellington, J. (1983). A taxonomy of scientific words. School Science Review, 64(229), 767-773.

West African Examinations Council (1991-1993). Regulations and syllabuses for the senior school certificate examination (Nigeria). Lagos: WAEC.

Westbrook, S. L., & Marek, E. A. (1991). A cross-age study of student understanding of the concept of diffusion. Journal of Research in Science Teaching, 28, 649-660.