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AN INVESTIGATION INTO SOME OF THE PROBLEMS AFFECTING THE TEACHING AND LEARNING OF BIOCHEMISTRY IN TRANSKEI COLLEGES OF EDUCATION

by

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ABSTRACT

The study investigated some of the problems experienced in the teaching and learning of biochemistry - a section in the Senior Certificate biology syllabus - in the Transkei Colleges of Education. Biochemistry is often labelled a difficult area, therefore, the study was an attempt to identify the problems encountered by biology teachers and lecturers in teaching biochemistry and by student-teachers in learning it.

Questionnaires were administered to final-year biology-major student-teachers in the colleges, and to the biology teachers and college lecturers. Examiners and subject advisers for biology were interviewed. The questionnaires required the respondents to identify the following:

1. Areas of biochemistry they find difficult.

2. Areas of biochemistry they find easy to understand.

3. Possible reasons for the students' poor performance in biochemistry.

4. Possible suggestions for improvement.

The student-teachers were further given a concept test to test their understanding of the concept 'photosynthesis'.

After analysing the data, the findings were used to make some recommendations, in an attempt to improve the teaching of biochemistry by the teachers and lecturers, and of the learning of biochemistry by the students.

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CHAPTER 1

INTRODUCTION AND STATEMENT OF THE PROBLEM

1.1 INTRODUCTION

Science education is one of the most carefully defined and systematically related areas of knowledge within the curriculum. Science is defined by Driver and Bell (1986) as ideas, concepts and theories to interpret the world.

Educationists have asked themselves questions about science teaching, like :- what is to be taught, how should it be taught for effective learning, and when can science be taught? A response to these questions may have led Education Departments to stipulate that students should study at least one science subject up to Matriculation.

Science education, though, has been a subject of much attention, with science teachers in many countries showing concern about the fact that science students neither understand nor see much point in the conceptually based science that they are taught at school. Some are able to learn the taught ideas for examination purposes, but cannot apply the ideas to everyday situations. The reason for this may be that the ideas taught are not properly linked together to form a framework of science concepts.

In Transkei, biology in particular has become more popular than the other science subjects, most probably because it does not require students to study mathematics as well. Biology, therefore, becomes the only science subject that most of the students study at Senior Certificate level.

The Transkei Department of Education adopted the Cape Education Department syllabus in all the subjects in 1979. One of the objectives of the Cape Education Department syllabus for biology is to develop in the pupils an ability to make critical, accurate observations of biological materials, and to make meaningful records of such observation. This objective can only be achieved if biology is taught and learnt effectively.

The increasing popularity of biology, compared with other Senior Certificate subjects, especially the other sciences, has led to an increased demand for teachers of biology. Unfortunately, this demand is greater than the supply of qualified biology teachers. As a result biology is being taught by underqualified or unqualified teachers who are not familiar with effective teaching strategies, and may be encouraging rote learning on the part of their pupils. For the students the difficulty of learning sections such as biochemistry would seem to be in the abstractness of the topics and the ineffectiveness of rote learning in these circumstances.

1.2 STATEMENT OF THE PROBLEM

In Transkei pupils study General Science up to Standard 7, then they have a choice of either biology or physical science or both from standard 8 to standard 10. The statistics from the examinations section of the Department of Education indicate that over the past 4 years (1984 - 1987) an average of 88% of the total number of standard 10 candidates registered for biology.

Gazi (1985), a researcher in Transkei, found a drop in the pass rate of biology between the years of 1977 to 1980 and 1981 and 1984. The former period was when Transkei was under the Department of Education and Training, and the latter was when Transkei had its own Department of Education. Concern about this drop in the pass rate has led to the present researcher undertaking an investigation into some of the factors relating to the teaching of biology and specifically the teaching of biochemistry.

In the Senior Certificate examiners' reports of the past four years, biochemistry has been mentioned as one of the areas of biology in which the candidates performed the worst. Gazi (1985) summarises this as follows:-

> Questions on biochemistry and on plant-water relations were poorly done. Particular attention should be given to plant biochemistry.
>
> Gazi, p. 113.

The examiner for the Standard Grade paper had the following observations:-

> Pupils exhibit weaknesses in the areas of biochemistry in respect of definitions of basic terms and the structure and functions of carbohydrates, fats and proteins.
>
> Gazi , p. 154.

In view of the above comments, there is reason to believe that biochemistry may well be contributing to the students' poor performance in biology.

Biochemistry was first introduced into the biology syllabus in 1968. It is therefore probable that teachers who qualified before 1968 received no training in biochemistry either at school or college. Even for those with science degrees, biochemistry would probably have been a minor topic. The absence of appropriate in-service courses on the teaching of biochemistry meant that teachers were required to teach this section of the syllabus without the necessary training.

The amount of biochemistry in the syllabus was increased in the 1975 syllabus for the newly differentiated Higher Grade and Standard Grade. For the younger teachers, who may have been taught biochemistry after its introduction, it is likely that they may have picked up misconceptions from their teachers. They may, in turn, have passed on these misconceptions to their pupils in their classes.

Preservice training in biochemistry is also seen as inadequate to equip the teacher-trainees with the necessary teaching skills. It was noted that in the past external examination papers for the college biology content (1984 - 1987), questions on biochemistry were very few or absent. This omission would encourage biology lecturers to ignore teaching biochemistry. The newly trained teachers could, therefore, on their arrival at the schools, have problems with the teaching of biochemistry.

The situation described above is made even more complex by the fact that Transkei is a developing country. Researchers in Transkei investigating factors contributing to the high failure rate in various subjects, namely Gazi (1982), Magazi (1982), and Qokweni (1983), have identified the following as the main factors:-

* a high pupil-teacher ratio both in the primary and high schools (60:1 in 1987);
* lack of well-equipped laboratories;
* underqualified teachers finding themselves forced to teach in senior secondary schools whereas they were trained to teach in junior secondary schools.

Magazi (1982) discovered a high teacher-mobility in the country, where an individual school does not have a stable staff, and pupils have to continually adapt to the teaching methods of new teachers. Sometimes it takes a long time to replace the teacher who has left, and pupils can remain a long time without a teacher for that particular subject.

1.3 THE PURPOSE OF THE STUDY

In order to investigate the problems encountered in the teaching of biochemistry it was decided to:-

(i) collect and analyse survey information on areas of biochemistry that the teacher-trainees and teachers regard as problem areas.

(ii) investigate student-teachers' understanding of photosynthesis using concept tests and concept maps. Photosynthesis had been identified as a problem area in biochemistry by researchers such as Bell (1984).

(iii) investigate the views of college lecturers and standard 10 teachers on the students' performance.

(iv) make recommendations on the basis of these investigations.

1.4 RESEARCH METHODOLOGY AND PROCEDURES

1.4.1 POPULATION AND SAMPLING

Questionnaires were administered by the researcher to final-year students majoring in biology in the Secondary Teachers Diploma (STD). Students in three of the STD Colleges were used, since the other two colleges offering biology did not have final-year students in the subject at the time of the research. Questionnaires were also administered to biology lecturers in the colleges and to the standard 10 biology teachers in the Umtata district.

1.4.2 BACKGROUND INFORMATION OF THE COLLEGES OF EDUCATION

This information is on the qualifications and experience of the lecturers, the subjects offered in the colleges and the number of students, at the time the research was undertaken.

The function of producing teachers for the more than 3 000 primary and secondary schools in Transkei is carried out by one private and ten public colleges of Education. Five colleges offer Primary Teachers Diploma (PTD) and the others offer Secondary Teachers Diploma (STD). The colleges are affiliated to the University of Transkei which, together with the Department of Education have set up a Colleges Affiliated Board to monitor and maintain the academic standards of the colleges. The University issues the diplomas and the Department is responsible for administration and finance of education in colleges.

For admission in the colleges the students must have a Senior Certificate. In addition for admission to STD a student must have passed each of the two intended teaching subjects with an E in Higher Grade or a D in Standard Grade.

The following table shows the enrolments in the STD colleges in 1986.

TABLE 1.1 : ENROLMENT IN STD COLLEGES IN 1986

College	STD 1		STD 2		STD 3		Total	%Men	%Women
	No.	% of total	No.	%	No.	%			
Butterworth	187	45,9	140	34,4	80	19,7	407	47	53
Cicira	187	37,2	176	35	140	27,8	503	47	53
Clarkebury	139	29,2	184	38,7	153	32,1	476	55	45
Maluti	179	38,1	160	34	131	27,9	470	44	56
							1856	48,25	51,75

The fifth college, Lumko, started in April 1987.

Table 1.2 shows the students enrolled for biology in the colleges.

TABLE 1.2: STUDENTS ENROLLED FOR BIOLOGY IN 1986

College	STD 1		STD 2		STD 3		Total	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total
Butterworth	40	21,4	40	28,6	12	15	92	22,6
Cicira	45	24	52	29,5	37	26,4	131	26
Clarkebury	43	23	54	29,3	none	yet	97	20,1
Maluti	29	16,2	26	16,3	25	19,1	80	17

The overall total for 1986 was 400, which is 21,6% of the total number enrolled for the STD course.

1.4.2.1 ACADEMIC STAFF AND QUALIFICATIONS

In 1987, out of a total of 237 lecturers, 102 were not qualified for teaching in the colleges. This number comprised a group of undergraduates and graduates who did not have professional training as teachers.

One factor that retards the improvement of the quality of the college staff is the mobility of qualified lecturers, who opt for promotion posts in senior secondary schools. The minimum qualification for a college lecturer is a degree in the appropriate subjects to be taught, a professional teachers certificate, and a teaching experience of at least 2 years in a comparable school.

The following is a table for the STD colleges of Education, as they appeared in the 1987 statistics.

All the statistics of the colleges was taken from an unpublished paper by the Transkei Department of Education to the Region Liaison Committee, titled:

> The state of existing teacher education facilities in the Republic of Transkei.
>
> Date : 04 January 1988.

TABLE 1.3 : ACADEMIC STAFF OF STD COLLEGES AND THEIR QUALIFICATIONS (1987).

Qualification	Butterworth		Cicira		Clarkebury		Maluti		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Std 8 & Prof Cert	–	–	–	–	–	–	3	8,3	3	2,5
SC & Prof Cert	5	17,2	5	14,3	8	36,4	10	27,8	28	23,0
Part degree only	–	–	1	2,9	–	–	–	–	1	0,82
Part degree & Prof Cert	–	–	–	–	–	–	4	11,1	4	3,3
Degree only	2	6,9	1	2,9	1	4,5	6	16,7	10	8,2
Sub-Total	7	24,1	7	20	9	40,9	23	63,9	46	37,7
Degree & Prof Cert	10	34,5	13	37,1	5	22,7	9	25,0	37	30,3
Honours Degree only	3	10,3	–	–	1	4,5	1	2,8	5	4,1
Honours Degree & Prof Cert	2	6,9	2	5,7	–	–	–	–	4	3,3
B. Ed & Prof Cert	3	10,3	8	22,9	3	13,6	2	5,6	16	13,1
Masters Degree & Prof Cert	4	13,8	5	14,3	4	18,2	1	2,8	14	11,5
Sub-Total	22	75,9	28	80,0	13	59,1	13	36,1	76	62,3
TOTAL	29	100,0	35	100,0	22	100,0	36	100,0	122	100,0

This shows that 34,4 % of these lecturers do not qualify to teach in the colleges. A bigger percentage (50%) comes from one college.

1.5 DATA COLLECTION

Data was collected by using the following instruments and techniques :- questionnaires, interviews and concept tests.

1.5.1 QUESTIONNAIRES

These were administered by the researcher to students in the three colleges which offer biology as a major subject. Section A of the questionnaire seeks general information about the students. They also had to state reasons why they chose biology as a major, and whether they felt they are equipped to teach biology when they go to teach. Section B has specific questions about biochemistry, seeking to find out the main problem areas, those areas they find easier to understand and the reasons why they find biochemistry difficult.

Questionnaires were also sent to the biology lecturers in the colleges of Education and to the standard 10 biology teachers in the Umtata District. In these questionnaires the researcher sought information about the teachers' experience, qualifications, areas in biochemistry in which they think the students' performance is particularly poor. They also had to suggest ways in which the students' performance could be improved.

The researcher is aware of the limitations of using questionnaires and interviews in a research project. One of the problems is designing a questionnaire which avoids open-ended, complex or leading questions. The questions may also be asked in a manner that will not enable the administrator of the questionnaire to get the information he or she needs for the research.

The other problem is to ascertain whether the questions will be interpreted in the same way by all the respondents. This means that the language used must be simple so that the respondents know exactly what is being asked. The researcher tried to overcome these limitations by having a series of informal interviews with the respondents not long after the questionnaire was administered. This was an attempt to substantiate information that could not be gathered from the questionnaire.

Interviews, too, may lack reliability, representativeness and validity, with the respondents attempting to anticipate what the interviewer wants to hear. In this way, data may be distorted by factors like suspicion. This may be more so if a teacher interviews students he or she teaches. Many people from various sections concerned with biology teaching were interviewed to eliminate using views from only a few people.

1.5.2 INTERVIEWS

The researcher conducted interviews with the examiners of the Standard Grade and Higher Grade papers in the Transkei Matriculation examinations; the lecturers in the In-Service Training Centre, who are experienced teachers; and some teachers who have been involved in marking biology over at least 3 years.

These interviews, except the one with the examiner for Standard Grade paper, were non-structured. Data collected through them was used in a qualitative manner to illuminate findings reported in the study.

1.5.3 CONCEPT TESTS

The data collected in the teacher-trainee questionnaire was used to identify the areas which the student-teachers find particularly difficult, and those they find easier to understand. To highlight any existing misconceptions (alternative frameworks), a concept test that was used by Bell (1984) to investigate 15 year-old students' understanding of plant nutrition in Britain, was given to the student-teachers. Bell investigated more specifically:-

- to what extent the pupils understand that plants carry out autotrophic nutrition and not heterotrophic nutrition.

- to what extent the pupils understand the role of light, chlorophyll and raw materials in photosynthesis.

- how they conceptualise the relationship between food energy and maintenance of plant metabolism.

The concept test consists of 3 questions, each requiring application of ideas about nutrition in a different context. The researcher chose this concept test for the teacher-trainees because most of the students indicated that photosynthesis is one of those topics they find easier to understand. If they had any misconceptions, hopefully the misconceptions would show in the test. (see Appendix II), p. 112.

The student-teachers were also given concepts on photosynthesis. The concepts were arranged randomly, and the student-teachers were required to rearrange them in the correct order. Then they had to write paragraphs or draw concept maps, to show that they understand how the concepts are linked. The researcher had to give a choice of either a concept map or a paragraph since some of the respondents were not conversant with concept maps.

CHAPTER 2

LITERATURE REVIEW

Recent research has been done on the students' understanding of various concepts of biology, and the effects of teaching strategies on their performance. Examples of these are:-

students' perception of the concept of life by Brumby (1982); some theoretical and empirical issues in the study of students' conceptual frameworks in science by Driver and Erickson (1983); concepts, misconceptions and alternative conceptions by Gilbert and Watts (1983); students' understanding of plant nutrition by Bell (1984); Understanding and misunderstandings of biology concepts by Marek (1986), and high school students' understanding of food webs by Griffiths & Grant (1985).

According to Osborne and Wittrock (1985) the motivation for the research has been the fact that the teaching and learning of science over the last two decades has not been successful in developing concepts in children which are:-

> acceptable and useful to children and which are also soundly based on our scientific culture and heritage.
>
> Osborne and Wittrock (1985) p113.

The research to improve the teaching and learning of biology, has been dominated by two major theories, namely Ausubel's theory of learning, and Piaget's developmental theory. The former theory has, according to Lawson (1988), focused attention on the ways the students acquire and use general scientific reasoning patterns.

Lawson shows further that a new research tradition focuses on the students' alternative conceptions or misconceptions. This research

> .... provides an opportunity to synthesize the best of available theory into a view of the learning process that leads directly to a theory of instruction. If this theory of instruction were implemented, it would produce learners, not only with adequate understanding of specific concepts, but with truly general transferable reasoning skills as well.
>
> Lawson (1988), p. 266

This activity, though, requires an active participation from both the teachers and the learners. Bigge (1982) has stated that the learner on one hand should actively construct his knowledge through relating in-coming information to a previously acquired psychological frame of reference. Each person should select and transform information, and construct hypotheses in the light of inconsistent evidence.

The teachers, on the other hand, should bear in mind that students adopt concepts which to them seem logical and coherent, and which influence the rate and extent of learning in science classrooms. Teachers must therefore identify students' misconceptions and adjust instruction to focus on the obstacles that inhibit their understanding of scientific concepts.

Simpson and Arnold (1982) as quoted by Ostald and Haury (1984) made a study analysing the conceptual understanding on the basis of personal interviews and performance on written tests by about 500 students, aged between 11 and 16 years. They found great inadequacies in prerequisite understanding, and a gap between the actual concept attainment amoung students and the level of attainment assumed by the teachers.

In another study, Marek (1986) identified fundamental concepts in high school biology, and sought to measure students' understandings and misunderstandings of these concepts. He identified 'the cell' and 'diffusion', and used the tenth grade biology students as the subjects. He discovered that only 15,8% of these students demonstrated a sound understanding of the cell - a concept which is fundamental in biology.

In the light of these studies, it becomes clear that conventional teaching approaches often leave students' understanding of biological concepts undisturbed.

Researchers have therefore directed their efforts to creating conditions under which students are likely to exchange an old concept for a new scientifically accepted one. Minstrell (1983), quoted by Marek (1986) states that concept understanding remains nearly unchanged after instruction. As Marek makes no mention of the quality nor the level of instruction, it is unwise to generalise that instruction will not change the students' initial conceptions. It may be that the teaching procedure should include helping students to recognise their initial conceptions.

Yager (1986) is of the opinion that one reason for misconceptions in science students is that teachers do not recognise the preparation that the students receive at the lower levels. They tend to downgrade the science that the students have previously experienced, regardless of its quality. Most teachers do not identify science concepts they want their in-coming students to know. As a result, science seems to be unrelated to the students' real world.

In addition to this there is the inability of the students to understand a concept and to apply it. Stepans (1985) quotes a study that was designed to find out if children incorporate text book definitions into their personal world view, or whether the more primitive conceptions persist in spite of text books and teaching. The results suggested that the children were not capable of applying information covered in the text books. Most of the students interviewed did not understand the concepts even after studying them several times.

Stepans, therefore, concluded that students' inability to understand a concept and to apply information may stem from some of the following:-

- the concept is introduced too early
- the concept is not developed properly
- the concept is introduced only verbally
- no attention was given to what the child brought into the learning environment.

Some theories are discussed about the students' learning disabilities and how to attempt to solve them, especially in science and mathematics. Findings of research are summarised by Osborne and Wittrock (1985) as follows:-

* children have views about a variety of topics in science, from a young age and prior to formal teaching.

* children's views are often different from scientists' views and are frequently not well-known by the teachers.

* children's views can remain uninfluenced or

be influenced in unanticipated ways by science teaching.

Driver and Erickson (1983), in using the constructivist approach, suggest that among science education researchers interested in children's ideas, there is a shared commitment to some form of constructivist psychology. One model that has come out of this approach is the generative learning model whose fundamental premise is:-

> that people tend to generate perceptions and meanings that are consistent with their prior learning. To construct meaning requires effort on the part of the learner, and links must be generated between stimuli and the stored information.
>
> Osborne and Wittrock (1985), p.64

The generative learning model is concerned with the influence of existing ideas on what input is selected and given attention, the links that are generated, the construction of meaning and the evaluation and subsumption of the constructed meanings. Students construct ideas about their world, which are determined by their prior experiences and existing ideas. This, together with their everyday use of language cause them to develop ideas which are different from those of scientists.

Osborne and Wittrock (1985) are of the opinion that this model accounts for the frequency with which children's ideas are influenced in unanticipated ways by classroom experiences. A teacher has a lack of control in ensuring that specific constructions occur and that existing ideas are influenced in the ways hoped for.

This may be caused by the fact that children are often satisfied with their own explanation of phenomena, or, they generate links from the sensory input to fit into their current ideas, or they resist major restructuring.

All these theories lead to a search for appropriate teaching strategies that would enable the learner to link the new information with his existing body of knowledge. One of these strategies is concept-mapping. This strategy was introduced by Novak and Gowin (1984) as a technique based on Ausubel's theory of meaningful learning. Novak was of the opinion that concept - mapping provides an opportunity for creative, meaningful representation of students' knowledge. Students who master this technique emerge with an understanding that real knowledge involves more than rote-learning, and that comprehension demands the forging of links between new ideas and those already possessed.

Brumby (1983) suggests that concept maps may have use as a teaching tool, as a map which explicitly shows learners the importance of linking the new and the existing knowledge. A learner preparing a concept map of a topic he has learned will have to actively relate new and old ideas, thereby overcoming rote learning of small isolated areas of knowledge.

Some methods of drawing concept maps advocate a hierarchical arrangement on the paper, with the general, most inclusive concepts at the top leading down to more specific concepts. Others tend towards a central position for the most general concepts with the other concepts radiating outwards from it.

The following steps are given by Arnaudin et al (1984) adapted from Novak et al (1980) :-

* Read a short section of a book.
* Identify major concepts by listing or underlining.
* List the concepts from the most general to the most specific.
* Write the most inclusive concept at the top of the map. Link it to the less inclusive and label all linking lines with words.
* Try to branch out, and make cross links.

Arnaudin et al, (1984), 118.

Concept maps aid learning during individual study, during classroom instruction and as a tool to evaluate pupils' learning. They provide a two-dimensional representation of the learner's structure of knowledge in a discipline. According to Feldsine (1987) concept mapping encourages students to become active participants in their learning, since they learn as they construct the maps. It also encourages them to form a unified picture of chemical concepts.

Stuart (1985) suggests the following assumptions underlying the use of concept maps:-

> * Concept maps are equivalent to thinking processes - either to the whole process or to some understood part of the process.
>
> * the drawing of concept maps aids understanding and/or recall by the learner.
>
> * it is possible for the instructor to use the concept mapping technique to make diagnoses about a learners' performance on a topic.
>
> Stuart (1985), p. 74

Finally, some research has been done on pupils' understanding of photosynthesis. It is important that biology students understand the concept of photosynthesis, because of its links with many other areas of biology. Photosynthesis is a process by which radiant energy from the sun is trapped by green plants, and converted to chemical energy. This energy becomes locked up in carbon compounds which are end-products of photosynthesis.

Green plants are important producers in both terrestrial and aquatic ecosystems, because of their ability to manufacture their own food during photosynthesis.

It is, therefore, essential for biology students to understand this concept, and the role that photosynthesis as a process, plays in biology. In her research on students' understanding of photosynthesis in Israel, Stavy-Yehudit (1988) found that adults who were doing Biology as a non-major, showed very little understanding of the essential role of photosynthesis in the ecosystem. Most of them perceived both respiration and photosynthesis as a gas exchange.

Bell (1984) attempted to investigate the understanding of plant nutrition by 15 year olds. She discovered that most of the respondents had a vague understanding of plant nutrition. The researcher has subsequently adopted the concept tests used by Bell (1984), and used them on teacher-trainees to find out whether they would have the same misconceptions. The assumption is that if students who are being taught in their mother tongue can experience some serious misconceptions, then it will be worse with Transkei students who are taught in a foreign language.

CHAPTER 3

DATA PRESENTATION AND ANALYSIS OF QUESTIONNAIRES

3.1 STUDENTS' QUESTIONNAIRES

STD is a 3 year course in which a student majors in two subjects in which he/she has performed the best in the matriculation examinations. For some students, however, this is not always the case and they major in a particular subject because that is the only stream where there is still a vacancy.

During the three years, the student-teachers are given a thorough revision of the content of the standards 8 to 10 syllabus, as well as the appropriate subject methodology.

Questionnaires were administered to 87 final-year respondents but only 78 of those were filled in fully, the rest had most of the questions left bank. This represented a 89,7 % return.

3.1.1. STUDENT-TEACHERS' PERSONAL INFORMATION

TABLE 3.1 : STUDENT-TEACHERS' PERSONAL INFORMATION

n = 78

AGE	16-20		Above 20		No Response	
	No.	%	No.	%	No.	%
	6	7,7	69	88,5	3	3,8

Symbols in Matric	A - B		C - D		E - F	
Biology	No.	%	No.	%	No.	%
	4	5,1	43	55,1	31	39,8

Grade	HG		SG		No response	
	No.	%	No.	%	No	%
	71	91	5	6,4	2	2,6

The age of the student-teachers was noted in order to compare their responses with those of the 15 year-old pupils used by Bell (1984) in investigating their understanding of plant nutrition.

From the table, 60,2 % of the respondents obtained symbols ranging from B to D in the matric examination, no students obtaining an A symbol, and 91% of the respondents wrote biology on Higher Grade.

TABLE 3.2 : STUDENT-TEACHERS' REASONS FOR CHOOSING BIOLOGY AS A MAJOR N=78

RESPONSE		No.	%
Students' success in the subject			
1.	I like/understand it better than other subjects.	32	41,0
2.	I passed it better in standard 10.	2	2,6
Nature of the subject matter			
3.	It is practical.	14	17,9
4.	I am interested in teaching/learning about nature.	13	16,7
5.	It is interesting/easy.	8	10,3
6.	It teaches me the way living organisms live.	4	5,1
Students' view of teaching			
7.	It is the only subject I can teach successfully.	4	5,1
8.	To improve the standard of biology teaching.	1	1,3

The responses have been divided into categories as shown in the table. 43,2% of the respondents chose biology because they performed better in it than in the other subject. 50% of them, though, chose it because of its nature. It is interesting to note that most of these respondents chose biology because it is practical, inspite of the fact that students generally complain that there is a lack of practical work in the teaching of biology in the schools.

The remaining respondents expressed their views of biology teaching, with one of them claiming that it is the only subject he could teach successfully.

TABLE 3.3 : STUDENT-TEACHERS' RESPONSES ON BIOCHEMISTRY

N = 78

RESPONSE	No	%
Easy	67	85,9
Difficult	10	12,8
No response	1	1,3

Asked whether they are equipped to teach biochemistry they responded in the way shown in the table below:-

TABLE 3.4 : RESPONSES ON HOW EQUIPPED THE STUDENT-TEACHERS FEEL TO TEACH BIOCHEMISTRY

Response	No	%
Yes	65	83,3
No	12	15,4
No Response	1	1,3

For those who felt they were not equipped to teach biochemistry the following reasons were forthcoming:-

TABLE 3.5 : REASONS WHY STUDENTS FEEL ILL-EQUIPPED TO TEACH BIOCHEMISTRY

Reasons		No
1.	There are difficult chapters. Biochemistry is difficult.	3
2.	I do not understand it, therefore I cannot teach it.	3
3.	I did not study it in Standards 8 & 9.	2
4.	Certain topics were not taught thoroughly.	1
5.	I need to know more of it.	1
6.	It contains a lot of practicals.	1
7.	It involves a lot of physical science in which I am not interested.	1

n = 12

3.1.2 HOW THE STUDENT-TEACHERS FIND BIOCHEMISTRY

85,9% of the respondents claimed that biochemistry was not too difficult for them to understand, while 12,8% found it difficult. The remaining 1,3% did not respond to the question.

In some respects this was a rather surprising response as biochemistry is considered by teachers to be a difficult subject area. The validity of the response was further explored. Informal interviews with the students showed that they were under the impression that biochemistry comprises only the biological compounds and the nucleic acids. They did not recognise the other topics as falling under biochemistry, until they were shown the entire list of topics by the researcher in the questionnaire. One wonders, therefore, whether the responses to this question were not influenced by this misconception since they responded to this question before they saw the list of topics.

3.1.3 HOW EQUIPPED THEY ARE TO TEACH BIOCHEMISTRY

83,3 % of the respondents felt equipped enough to teach biochemistry in the schools. This tallies with the respondents who felt that biochemistry was not difficult. Equally, the validity of the responses to this question is questionable. These responses highlighted the unreliability of unpiloted and unrefined questionnaires in getting the information.

The remaining respondents who felt they were not equipped to teach biochemistry gave a variety of reasons. These range from the fact that biochemistry is difficult to a need to know more about it.

3.1.4 LIST OF BIOCHEMISTRY TOPICS

1. Chemical Composition of Protoplasm
2. Relevant functions of water and proteins
3. Nucleic acids
4. Protein synthesis and gene mutations
5. Biological compounds and nutrients - water, macro and micro- nutrients; organic compounds - carbohydrates, lipids, proteins, vitamins.
6. Enzymes and Co-enzymes
7. Photosynthesis
8. Cellular respiration
9. Chemical processes of digestion

Respondents were requested to identify 3 areas which they feel are the most difficult. A few of these responses did not indicate 3 areas. Of the 234 topics expected from all the respondents, 206 were given. This constitutes a response of 88%.

They were further requested to identify 3 areas which they find easiest to understand. Of these, 217 responses were received, a response of 92,7%. From these responses, the following two tables were drawn, indicating the order of preference.

TABLE 3.6 : TOPICS STUDENTS FIND MOST DIFFICULT

n = 206

TOPIC		No	%
1.	Protein Synthesis	52	25,4
2.	Enzymes and Co-Enzymes	44	21,4
3.	Cellular Respiration	27	13,1
4.	Nucleic Acids	26	12,6
5.	Biological Compounds	23	11,2
6.	Chemical Process of Digestion	13	6,3
7.	Protoplasm	08	3,9
8.	Functions of Water and Proteins	07	3,4
9.	Photosynthesis	06	2,9

TABLE 3.7 : <u>TOPICS STUDENTS FIND EASIER TO UNDERSTAND</u>

n = 217

TOPIC		No	%
1.	Photosynthesis	55	25,3
2.	Chemical Processes of Digestion	33	15,2
3.	Nucleic Acids	29	13,4
4.	Protoplasm	28	12,9
5.	Functions of Water and Proteins	24	11,1
6.	Cellular Respiration	17	7,8
7.	Enzymes and Co-enzymes	13	6,0
8.	Biological Compounds	11	5,1
9.	Protein Synthesis	07	3,2

One would have expected table 3.7 to be an inverse of table 3.6. The topics at the extremes of the tables match quite well, with the topics rated most difficult in table 3.6 being at the bottom of the list of the easier topics. As could be expected, those in the middle of the tables show some discrepancies. Nucleic acids, for example, rate quite high in the list of difficult topics, and it also rates high in the list of easy topics. This discrepancy, again, shows the unreliability of questionnaires.

Photosynthesis has been identified as one of the easiest topics for the student-teachers to understand.

Subsequent interviews with the students revealed that by photosynthesis most of the respondents meant the general definition of the concept, without going into the details of the light and dark phases.

3.1.5 STUDENT-TEACHERS' POSSIBLE REASONS WHY BIOCHEMISTRY IS DIFFICULT TO UNDERSTAND

A table was drawn from the responses which were arranged in categories according to their similarity.

The questions used were open-ended and then the responses were categorised into the following categories:-

(i) Nature of the subject
(ii) Role of the teacher
(iii) the student motivation.

TABLE 3.8 : STUDENT-TEACHERS' REASONS N = 164

RESPONSE

Nature of subject		No	%
1.	Has a lot of chemistry which was not done by the others earlier on.	41	25
2.	Too abstract, therefore becomes vague.	23	14,0
3.	Needs a lot of concentration and cannot be related to real life.	11	6,7
4.	Needs logical thinking.	3	1,8

5.	Biological cycles are long and confusing.	5	3,0
6.	Formulae are similar and easy to mix up.	3	1,8
7.	Consists of difficult diagrams / structures.	4	2,4
8.	Some terms are impossible.	3	1,8
9.	Cannot be studied without a teacher's help.	1	0,6
10.	Has a lot of calculations.	3	1,8
	<u>Sub-Total</u>	97	59,1

<u>Teaching strategies</u>

11.	Not done practically by teachers - since there is a lack of equipment in the schools.	24	14,6
12.	Most teachers do not understand it themselves, and therefore do not teach it properly.	13	7,9
13.	No teaching aids are used.	15	9,1
14.	Teachers do not allow pupils to participate in the lessons.	4	2,4
15.	Teachers teach it late in the standard 10 year.	1	0,6
	<u>Sub-Total</u>	57	34,8

<u>Student motivation</u>

16.	Pupils have a negative attitude towards it.	6	3,7
17.	Lack of motivation.	2	1,2

18.	Encourages memorisation and vote learning although it is difficult even to memorise.	2	1,2
	Sub-Total	10	6,1

Nature of the subject matter

59,1% of the responses fall under this category. They range from the complaints of a large amount of chemistry in biochemistry, the abstractness of biochemistry, the difficult diagrams and structures, to a lot of calculations in biochemistry. At least three respondents gave the latter as a reason. What they meant about it, the researcher could not make out, since there are no calculations in biochemistry. This may be attributed to a language problem.

What bothers the student-teachers the most about the amount of chemistry in biochemistry is that most of them did a minimum amount of chemistry in the junior secondary classes. So they feel that the amount of chemistry in general science is not adequate as a basis for biochemistry.

Respondents also felt that biochemistry is too abstract to understand easily, and it therefore becomes vague. This is where models, experiments and other teaching aids could help the students' understanding of the concepts. Since there is a serious shortage of equipment in Transkei schools, these concepts can only be taught in an abstract and theoretical manner.

At the same time, the lack of equipment for the teaching of biochemistry is sometimes used as an excuse. Some of the experiments would not necessarily lead to greater understanding of the concepts. Practical work needs to be enhanced by a thorough explanation of terms and group discussions. If this is done by a teacher who understands biochemistry, it could be more effective.

The role of the teacher

The responses in this category focus on the role of the teacher in the teaching of biochemistry. They range from the failure of teachers to do practical work and to allow students to participate in the lessons, to a lack of understanding of biochemistry by the teachers themselves. The students feel that because the teachers do not understand biochemistry, they teach it late in the year. The students, therefore, do not have a chance of concentrating on it long enough before they write examinations. From interviews with the students, it was discovered that some teachers do not even attempt some sections of biochemistry.

The role of the students

It is interesting to note that only 6,1% of the responses focus on the role that students play in the learning of biochemistry. These responses include the students' negative attitude towards biochemistry, their lack of motivation and foundation. Apparently the students have adopted the teachers' attitude towards biochemistry, and consequently they believe that it is a difficult section. The students feel that biochemistry should be introduced at an earlier stage to form foundation for the work done in standards 9 and 10.

3.1.6 STUDENT-TEACHERS' SUGGESTIONS FOR IMPROVEMENT

The suggestions have been categorised under teaching strategies, role of the teacher and the role of students.

TABLE 3.9 : STUDENT-TEACHERS' SUGGESTIONS

n = 186

RESPONSE		No	%
1.	Practical work should be done and should involve the pupils.	50	26,9
2.	Teaching aids/models should be used.	22	11,8
3.	Pupils should be encouraged to have group discussions.	19	10,2
4.	Thorough explanations of terms by		

	the teacher.	14	7,5
5.	The theory must be mastered.	4	2,2
6.	Must be taught from as early as standard 5.	7	3,8
7.	Must be made more interesting to motivate students.	12	6,4
8.	Physical science for standard 8 to be compulsory.	3	1,6
9.	Must be excluded from biology.	1	0,5
	<u>Sub-Total</u>	132	71,0
10.	Must be taught by teachers who understand it.	16	8,6
11.	The importance of biochemistry must be made clear by linking it with real life.	10	5,4
12.	Demonstrations by teachers and manipulation materials by pupils.	5	2,7
13.	Teachers should prepare thoroughly.	6	3,2
14.	Work sheets must be provided.	3	1,6
	<u>Sub-Total</u>	40	21,5
15.	Students must have a background of chemistry.	8	4,3
16.	Students must use effective studying methods.	3	1,6
17.	Pupils to be given homework.	3	1,6
	<u>Sub-Total</u>	14	7,5

Teaching Strategies

The use of teaching aids, models, practical work and group discussions by students range very high in the students' recommendations. It is their feeling that the teachers use the lecture method in this area of the work, and do not give a thorough explanation of terms.

The students feel that for biochemistry to be understood properly, the teachers and students should master the theory (with the help of experiments where possible), and that it should be made interesting.

They feel they could understand it better if it could be introduced earlier. In addition to this, they feel that they need to have a stronger background in chemistry for them to understand biochemistry. It therefore becomes apparent that the students feel that the chemistry they study in Standards 6 and 7 is not adequate for a sound understanding of biochemistry.

The Teachers' Role

The students seemed to be aware that some of the biology teachers have problems in the teaching of biochemistry, even if they are good in the other areas of biology. They also felt that biochemistry should not be isolated from the other areas of biology, but must be linked with them and with real life situations. This would hopefully help the students to understand it better.

The students feel that the teachers should prepare thoroughly when they teach this section. Interviews with the students revealed that some teachers either avoid teaching it, or when they do, their attitude is such that the students are discouraged from asking questions.

Another suggestion is that the teachers should involve the students when performing demonstrations and experiments. They should also encourage the students to manipulate the materials themselves.

The Role of the Students

The student involvement includes students asking questions, and taking part in group discussions and practical work. The students feel that their study skills in biochemistry should be different from those they use in the other sections of biology or other subjects. A change of attitude towards biochemistry to a more positive one may make them appreciate and understand it.

3.2 TEACHERS'/LECTURERS' RESPONSES

The presentations of the responses of the lecturers and teachers of biology in colleges and schools respectively will be shown under the following sections:-

SECTION A consists of the general information about them, namely qualifications, highest levels in which biology was passed and their teaching experience.

SECTION B involves the questions about biology in general and biochemistry in particular. These include sections of biochemistry that the students find difficult to understand, those they find easier to understand, reasons for the students' poor performance and suggestions for improvement.

Altogether 15 teachers, selected at random from the Umtata district high schools, responded to these questionnaires. In addition questionnaires were given to the 10 lecturers of biology or general science in the colleges.

3.2.1 GENERAL INFORMATION

TABLE 3.10 : TEACHERS' AND/LECTURERS' QUALIFICATIONS

n = 25

ACADEMIC			PROFESSIONAL		
QUALIFICATION	No	%	QUALIFICATION	No	%
M.Sc	3	12	B.Ed	4	16
B.Sc (Hons)	6	24	U.E.D. or H.D.E.	4	16
B.Sc	6	24	Dip. in Educ. (non-grad)	8	32
B.A.	5	20	S.S.T.C	3	12
MATRIC	5	20	J.S.T.C	2	8
			A.C.P	1	4
			H.P.T.C	1	4
			None	2	8

TABLE 3.11 : TEACHERS AND LECTURERS' HIGHEST LEVEL IN WHICH BIOLOGY WAS PASSED

n = 25

	No	%
M.Sc	2	8
B.Sc (major)	9	36
Course II	3	12
Course I	4	16
A- level	1	4
Std 10	6	24

TABLE 3.12 : TEACHERS' AND LECTURERS' EXPERIENCE IN YEARS

N = 25

YEARS	No	%
0 - 5	5	20
5 - 10	9	36
10 - 15	4	16
15 and above	7	28

60% of the teachers interviewed hold B.Sc. degrees and above. 20% hold a B.A. degree and the remaining 20% have matric as the highest academic qualification. 8% of the interviewed teachers do not have either a professional or academic qualification but are still studying for a degree at the local university.

The teachers who hold B.A. degrees from South African Black Universities have an arts-orientated degree which does not have biology as a major. The respondents with matric are not qualified to teach biology at Standard 10 level, but due to a lack of qualified teachers they teach to Standard 10 level.

In the STD Colleges of Education, the minimum qualification for lecturers is a relevant junior degree and a professional qualification. All the STD lecturers interviewed are qualified to teach biology at this level.

6% of the respondents have post-graduate teachers' professional certificates, which equip them to teach students in secondary schools. 12% of the respondents hold SSTC which is a non-graduate diploma which equips the teacher to teach in senior secondary schools. The other 12% hold JSTC, a post-matriculation diploma in which teachers are trained to teach in junior secondary schools. These teachers, therefore, are not trained to teach in senior secondary schools. Of the teachers interviewed, 32% do not qualify to teach either at high school or at college.

44% of the interviewed teachers and lecturers have passed biology at degree level and above. This means that they have majored in either zoology, botany or both, since in most South African universities biology is not offered as a course above Course I.

12% did it up to Course II level and 16% up to Course I level. The remaining 28% did biology up to matric. The latter are likely to be experiencing problems with some aspects of biology, since they do not have any supplementary knowledge on the subject they teach.

With regard to experience, 28% of the respondents have more than 15 years experience, while the rest have less. The researcher particularly asked this question to find out how many teachers were possibly taught biochemistry at school. Biochemistry was introduced into the biology syllabus in 1968, therefore, all those who studied biology before 1968, did not study it. This means that they are some of the teachers who have had to teach biochemistry without studying it.

3.2.2 TEACHER/LECTURER PERCEPTIONS OF THE SECTIONS OF BIOCHEMISTRY THAT THEY THINK STUDENTS FIND DIFFICULT

Each respondent was required to supply at least three areas which students find difficult. Some, though, supplied less than three.

TABLE 3.13 : TOPICS THAT TEACHERS/LECTURERS PERCEIVE THE STUDENTS FIND DIFFICULT

n = 67

TOPIC		No	%
1.	Cellular respiration	19	28,4
2.	Photosynthesis	14	20,9
3.	Functions of Water and Proteins	7	10,4
4.	Protein Synthesis and Gene Mutations	7	10,4
5.	Biological Compounds	7	10,4
6.	Nucleic Acids	5	7,5
7.	Protoplasm	3	4,5
8.	Chemical Process of Digestion	3	4,5
9.	Enzymes and Co-Enzymes	2	3,0
	TOTAL	67	100

TABLE 3.14 : TOPICS THAT TEACHERS/LECTURERS THINK THE STUDENTS FIND EASY

n = 9

TOPIC		Number
1.	Digestion	3
2.	Functions of Water and Proteins	3
3.	Protoplasm	1
4.	Biological Compounds	1
5.	Enzymes and Co-Enzymes	1

There was 89,3% response on the question on the topics that the teachers think students find difficult to understand; whereas there was only 12% response on those the students find easier to understand. This seems to indicate that the teachers feel that students have problems with biochemistry.

Table 3.13 shows the order of difficulty of topics as arranged by the teachers/lecturers. The teacher-trainees, on the other hand arranged the topics as follows:-

1. Protein synthesis and gene mutations.
2. Enzymes and co-enzymes.
3. Cellular respiration.
4. Nucleic acids.

5. Biological compounds.

6. Chemical processes of digestion.

7. Chemical composition of protoplasm.

8. Relevant functions of water and proteins.

9. Photosynthesis.

It is interesting to note that the student-teachers regarded photosynthesis as relatively easier than other topics, yet the teachers range it quite high in the list of difficult topics for the students.

According to the teachers' responses the topic 'enzymes and co-enzymes' is not difficult for students to understand, yet the students rated it as a difficult topic.

What does this negative correlation imply? Does it imply that students have alternative frameworks that make them think they understand photosynthesis when in fact they do not? Or are the teachers themselves not sure of their concepts?

3.2.3 : TEACHERS'/LECTURERS REASONS FOR STUDENTS' POOR PERFORMANCE

The reasons were categorised under the nature of the subject and poor teaching in schools.

Nature of the Subject:-

1. Lack of chemistry/physical science background.

2. Biochemistry is not considered a difficult part in the syllabus.

3. Lack of correlation of biochemistry with the rest of biology.

4. Unrelated subject combination. (Colleges of education).

Poor Teaching:-

1. Pupils are not taught properly.

2. Lack of motivation by the teachers.

3. Teachers are not qualified enough to teach at the levels at which they teach.

4. Lack of equipment for experiments.

5. Language problems which lead to problems of understanding.

Of the reasons stated by the student-teachers, the five rated the highest are the following:-

1. Has a lot of chemistry which is not studied earlier on.

2. Not done practically - since there is a lack of equipment in schools.

3. Too abstract and therefore becomes vague.

4. No teaching aids used.

5. Needs a lot of concentration and cannot be related to real life.

The teachers/lecturers gave the above as the most possible reasons. Both the teachers/lecturers and the student-teachers agree on two reasons as the most likely reasons for the students' poor performance in biochemistry. Both the teachers and student-teachers feel very strongly about the lack of chemistry or physical science background, which they think they need for understanding some concepts of biochemistry. They also feel strongly about the lack of equipment to perform biochemistry experiments.

3.3 LECTURERS' AND TEACHERS' SUGGESTIONS FOR IMPROVEMENT

These suggestions were categorised under the teachers' role and the students' role.

Teachers' Role:-

1. Teachers should teach biochemistry like they teach the other sections of biology.

2. In-service training courses should be held to upgrade the teachers' content knowledge and teaching strategies.

3. Illustrations and models should be used in this section since it is abstract.

4. New methods of teaching biochemistry should be invented.

5. Less qualified teachers should not teach it.

6. More biochemistry questions should be included in the compulsory sections of the question papers.

Students' Role:-

1. Students must do physical science at least up to Standard 8.

2. The negative attitude towards biochemistry should be changed.

3. Learners should be exposed to day-to-day biochemistry concepts.

4. Students should ask questions and have group discussions.

Student-teachers rated the following suggestions highest:-

1. Practical work should be done.

2. Teaching aids or models should be used.

3. Students must be encouraged to be involved in group discussions.

4. Must be taught by teachers who understand it.

5. Thorough explanation of the terms by the teachers.

Some of the lecturers' and teachers' suggestions are vague and do not give the researcher much to work on. Under the teachers' role, suggestions 1 and 4 need some explanation.

Most of the suggestions are common for both the teachers and the student-teachers. While the suggestions may seem reasonable, the practical reality is that the suggestions cannot be implemented. Standard 8 is no longer (since 1988) an external examination class, therefore students who have chosen physical science in Standard 8 will have to continue with it to Standard 10. The conditions in the schools cannot improve over a short period because of the costs involved.

Therefore, solutions should be sought, to enable teachers to use teaching stretegies which will not require practical work for the students to understand the concepts. They should be strategies which will make use of available resources, and which will link the students' existing knowledge with the new concepts that the teachers are presenting to the students.

CHAPTER 4

ANALYSIS OF THE CONCEPT TESTS

The respondents were given a concept test that was used by Bell and Brook (1984) to 15 year-olds in an investigation about the kinds of ideas some secondary school students have about aspects of plant nutrition, and to analyse the extent to which students use taught ideas in a meaningful way.

They responded to three questions, each requiring the application of ideas about plant nutrition in a different context. (see Appendix II, p. 112 for full questions and diagrams).

According to Bell (1984), the following are the accepted scientific responses:-

HAY-TODAY

A farmer cut his meadow for hay (feeding grass). He noticed that the grass he cut was green, but the stalks left were yellow..
How do you explain this ?

* Pigment cholophyll is responsible for the green colour in grass.

* In the absence of light, no chlorophyll.

* Grass blades at top are exposed to sunlight and are therefore green.

* Stalks at the bottom are shielded from the sun, therefore are yellow.

<u>VILLAIN</u>

In a science fiction book, a villain (wrong-doer) threatens to spray the countryside with a chemical that destroys chlorophyll (the green substance in plants). What effect will this have on plant life? Explain your answer as fully as you can.

* With no chlorophyll, plants would be yellow or white.

* With no chlorophyll, photosynthesis cannot occur.

* The plants would be unable to manufacture their own food.

* Without a source of food, plants would die.

GROW TREE

A small tree is planted in a meadow. After 20 years it has grown into a big tree, weighing 250 kg more than when it was planted.
Where do the extra 250 kg come from? Explain your answer as fully as you can.

* Plants take in water from the soil, through roots, and carbon dioxide from the air.

* Using water and carbon dioxide in the presence of chlorophyll, plants convert light energy into chemical energy and manufactures food substances such as glucose.

* Some of the energy-containing substances are used for making new plant cells, which gives the plant its extra weight.

4.1 STUDENT-TEACHER RESPONSES

In all the questions, three categories of answers were identified, namely:-

(i) Responses which included all or some of the relevant scientific ideas.

(ii) Responses that are vague and/or include alternative explanations about plant nutrition.

(iii) Responses that provide no indication that the respondent understands the questions.

4.1.1. HAY-TODAY

Category 1

54,5% of responses contained most of the relevant ideas of the accepted answer to the question. Some of them were expressed well. The following are examples of the responses, and are direct quotes of the responses.

1. The stalks were not exposed to sunlight, which is the source of energy. Photosynthesis did not take place in the stem, chlorophyll was not activated.

2. The portion that was cut is green, has more chloroplasts because it is exposed to sunlight and photosynthesis takes place in that green part. The stalks are under cover therefore no or less photosynthesis takes place.

3. The grass is green because it has chlorophyll which enables photosynthesis to take place, but the stalks were yellow because they were not exposed to sunlight, so the colour changed to yellow. Photosynthesis could not take place in stalks since they were under the leaves.

4. The grass the farmer cut was exposed to sunlight so it carried out its photosynthesis. Stalks were not exposed to light because grass does not grow as single stalks, it is dense, therefore stalks are not exposed.

Within this category, some emphasize an absence of chlorophyll from the stalks because there are no chloroplasts. This gives an impression that the respondents believe that chloroplasts are only found in the leaves and not on the stalks. They do not offer a reason why stalks are yellow.

1. The stalks of this plant contain no chlorophyll, only the grass contains chlorophyll. Therefore the stalks depend on grass for their food. Stalks that were left cannot synthesize food, therefore they cannot grow.

2. The farmer removed leaves where photosynthesis takes place. The chlorophyll containing parts of the plant are on leaves, and therefore no place for manufacturing of plant food.

3. The green colour in the grass is caused by the presence of chlorophyll in the leaves, and that indicates that photosynthesis takes place. In the stalks there are no photosynthetic cells, therefore chlorophyll is absent since there is no photosynthesis takes place.

<u>Category 2</u>

36,5% of the responses did not give an adequate explanation, and were rather vague.

1. The stalks of the grass were under the shadow of the grass, so the sunlight was not available to the stalks.

2. The reason was that the grass was exposed to the sunlight and water evaporates more easily in aerial parts, whereas the stalks did not get sunlight for photosynthesis to take place due to shade of grass.

3. Since the stalks have no chlorophyll photosynthesis cannot occur and yellow colour indicates lack of chlorophyll. Since the stalks are exposed to the sun, and chlorophyll is gained as they grow photosynthesis occurs.

One notices that, although here and there the respondents in this category mention some of the correct aspects of photosynthesis, they get mixed up in the explanation. The problem of the language may be playing a role in this inability to explain.

Category 3

The remaining 9% showed a complete lack of understanding of the question and how to respond to it, as is shown by the following examples.

1. Green plants are fleshy but those without chlorophyll are hard and woody, so they cannot be swallowed with ease by the animals.

2. The grass as weeds obtain sunlight as well as nutrients from the soil. The stalks do not get enough sunlight so they lack nutrients from the soil.

3. The water that usually comes from the ground to the leaves through xylem vessels has been cut, now

water just evaporates and no photosynthesis taking place and no chlorophyll containing pigments on the leaves.

4.1.2 VILLAIN

All the respondents were aware that if the countryside was sprayed, and chlorophyll destroyed, photosynthesis would not take place. What differs was the extent to which the responses explained the phenomenon.

66,4% of the responses satisfactorily explained the relationship between chlorophyll, photosynthesis and the subsequent destruction of plants in the absence of chlorophyll.

1. The chlorophyll in the plants enable them to manufacture their own food through the process of photosynthesis. Without chlorophyll photosynthesis does not take place and the plants will ultimately die because they do not manufacture their own food.

2. The plants will not manufacture food and they will die, since photosynthesis does not occur in the absence of chlorophyll.

3. The plant life will be denatured. No chlorophyll, no life in a plant. Plants will not be able to manufacture its food because no photosynthesis will take place.

One response even went so far as to relate this with how man and animals which depend on green plants would also die, because of lack of oxygen and accumulation of carbon dioxide.

> ..... man and animals will suffer as they use oxygen which is produced by plants during photosynthesis. So there will be little oxygen available and too much CO_2 is liberated during breathing by animals, but not used as plants are not capable of manufacturing their own food.

Some of the remaining 33,6% of responses are rather confused in their explanations, as shown by these examples:-

1. The chemical used will block the stomata which is essential for gaseous exchange because of the layer accumulated. Carbon dioxide which is essential for photosynthesis will not perform its functions. That destroys the whole life of a plant.

2. If the chlorophyll is destroyed also the bacteria which thrive on the soil will stop their activities on the soil. Therefore the working of enzymes will stop.

3. Photosynthesis cannot occur, plants would become yellow and die, those that do not depend on dead organic matter for food like saprophytes, will survive.

4.1.3 GROW TREE

Apart from the aspects mentioned as the correct responses, some of the respondents mentioned other aspects of plant growth, like secondary thickening as playing a role in the increase in the tree size.

27,3% of the respondents gave a reasonably acceptable answer to the question.

1. The plant absorbs water and mineral salts. It gets CO_2 from its surroundings and is able to synthesize its own food, with the use of sunlight and chlorophyll. Food and water are transported by xylem and phloem to all parts of the plant. Cells then divide mitotically and give rise to a big tree.

2. Upon growth, the young plant manufactures its own food from its green leaves during photosynthesis which result in their growth in size and height.

3. The extra 250 kg that the tree gained were from the process of photosynthesis whereby food is manufactured by the tree. A tree receives water, mineral salts, nutrients etc and made it to gain 250 kg.

The other responses do not mention the role played by photosynthesis, but emphasise, the role of mitosis and absorption of nutrients from the soil.

1. The young tree absorbed water and mineral salts from the soil. Mitosis occurred rapidly and the plant increased in width and height.

2. The plant got its extra 250 kg from the nutrients that are in the soil, from water and sunlight. For a plant to get extra kilograms, fertile soil is essential.

3. The extra 250 kg comes from a tree since it gets mineral salts, water and food from the soil.

The rest relate the increase in weight to secondary thickening. No mention is made of photosynthesis and/or the use of carbon dioxide and water in the presence of chlorophyll.

1. Cell division has occurred. Secondary thickening helped by lateral meristem and primary growth occurred.

2. For a plant to grow bigger it should undergo secondary thickening as a result of cambium and pericycle in the stem. Cambial rings will be formed and annual rings, then the weight increases.

3. The plant obtains extra 250 kg through secondary thickening because phloem develops and thickens the tree, water and mineral salts strengthen the tree.

Two of the responses showed a total lack of understanding of the question.

1. As it grows it becomes bigger and strong and has more nutrients which make it stronger so this extra 250 kg comes from its strongness, growth and bigness.

2. At first the growth was inhibited by other plants. After some time these short plants die and are decomposed then the tree gets more nutrients and grows rapidly.

The diversity in these responses shows the following apparent misconceptions:-

* the plant gets its food from the soil and uses it to grow and increase in weight.

* Photosynthesis has nothing to do with the increase in weight of the plant. Food manufactured during photosynthesis is only stored for use by man and animals. This fact was established in subsequent discussions with the respondents and other students.

* The plants get their weight from mitosis and secondary thickening without connecting these two processes with photosynthesis.

These responses imply that the teachers should first find out what the students understand about plant nutrition, and try to correct any misconceptions. Then they can introduce new concepts which will link with the existing knowledge.

The overall percentage of responses with scientifically accepted ideas on plant nutrition in this research seemed greater than that obtained by Bell (1984), as shown by the following table:-

TABLE 4.1 : COMPARISON BETWEEN BELL'S RESPONSES AND THOSE OF TRANSKEI STUDENT-TEACHERS

	Bell %	Transkei %
1. Responses including all or some of the scientifically accepted ideas		
1.1 HAY TODAY	30	54,5
1.2 VILLAIN	38	66,4
1.3 GROW TREE	38	27,3
2. Responses that provide no indication of understanding of the concepts		
2.1 HAY TODAY	21	9
2.2 VILLAIN	19	33,6
2.3 GROW TREE	19	5,2

It nevertheless caused concern that student-teachers, in their last year of training, still showed such obvious misconceptions about plant growth. It becomes more so since this is one of the very few topics of biochemistry they chose as easiest to understand. Moreover, whereas Bell's respondents were 15 year olds, the respondents in this research were on the average 20 year olds.

4.2.3 FINDINGS OF THE STUDENTS' CONCEPT MAPS

A concept map is defined by Malone and Dekker (1984) as a "device to enable either the student or the teacher to explicitly represent a number of concepts."

The map which consists of concepts linked by propositions, demonstrates the manner in which new knowledge has been integrated with an existing knowledge structure. The insertion of propositions linking various concepts is a most important component in the use of this tool, since they (propositions) provide an indication of what understanding exists. and the depth of that understanding.

The respondents to this concept-test had been exposed to the concept-mapping skill at the beginning of their third year of study when the researcher started teaching them. At this stage of their training the student-teachers resisted any "new" skills the "new" lecturer introduced to them. This was observed more clearly when they were compared with the way the first year student-teachers accepted the same skill and adopted it. This attitude of the final-year students explains why their concept maps did not give much indication of their understanding of photosynthesis.

The accepted concept maps should look like the following:-

Concept Map 1

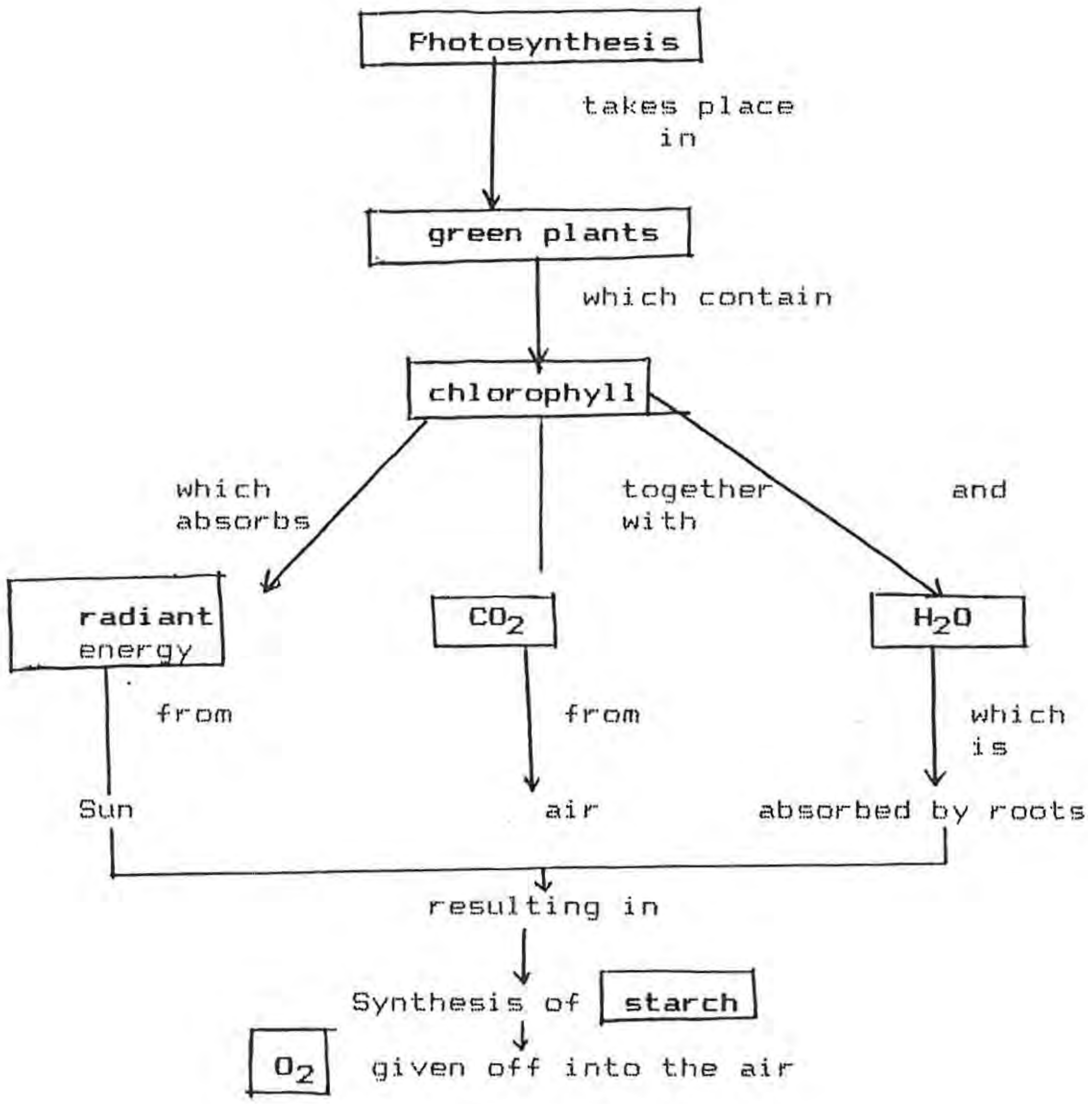


Figure 1

Concept Map 2

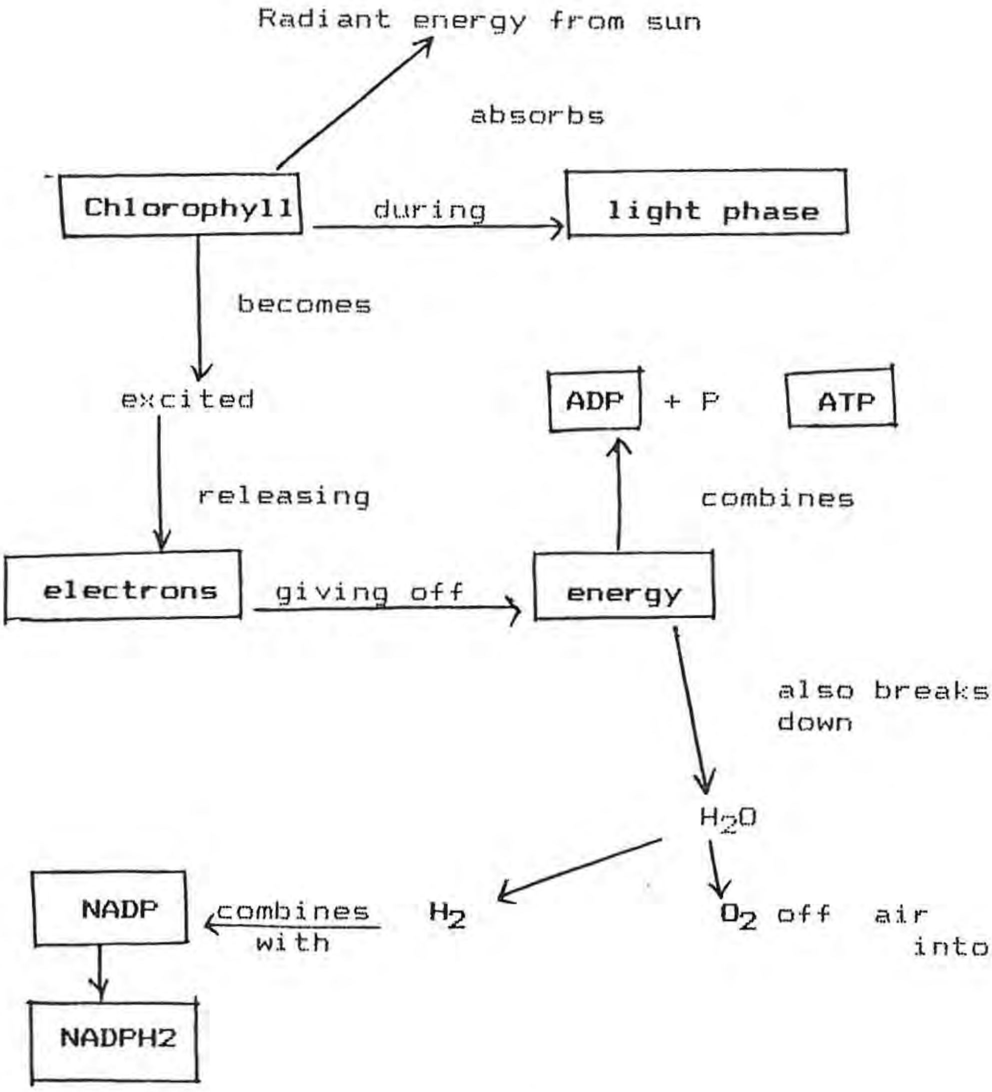


Figure 2

Concept Map 3

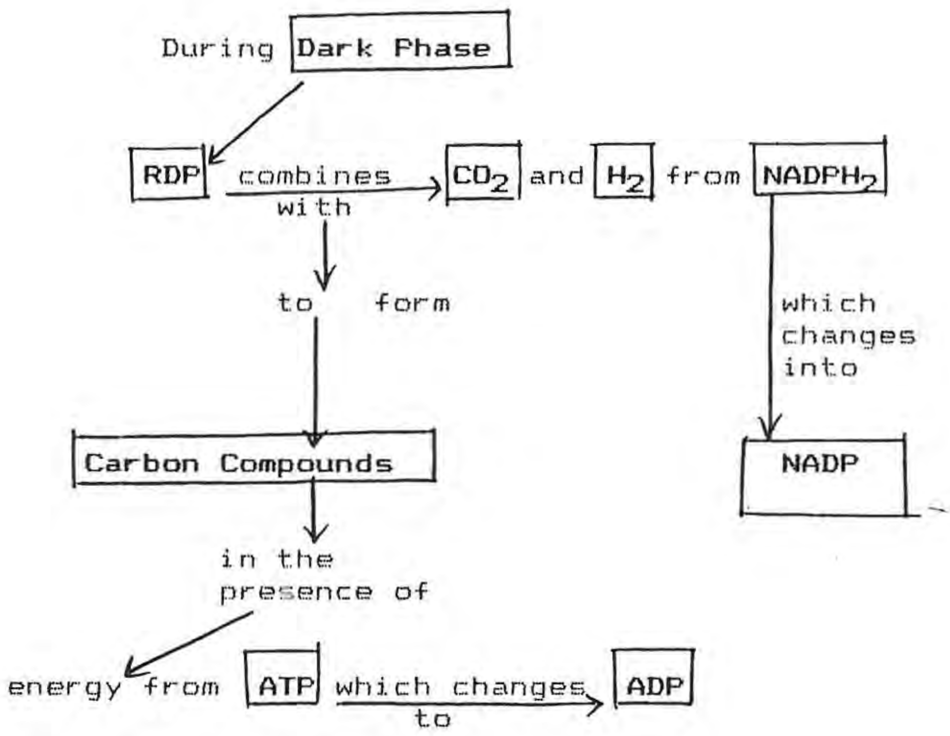


Figure 3

No two concept maps are the same, but it is possible to score concept maps. According to Stuart (1985) one way of scoring a concept map is to count the number of correctly used technical terms and to turn them into a percentage of the total number of terms in the concept map. Also, each correct relationship given along the connecting line should score a point. A number of criteria like hierarchy, branching and moving from general to specific are also considered.

63,7% of the respondents to the concept test used the concept maps. Of these only 14,3% gave concept maps containing some linking words. An example of these is the following:-

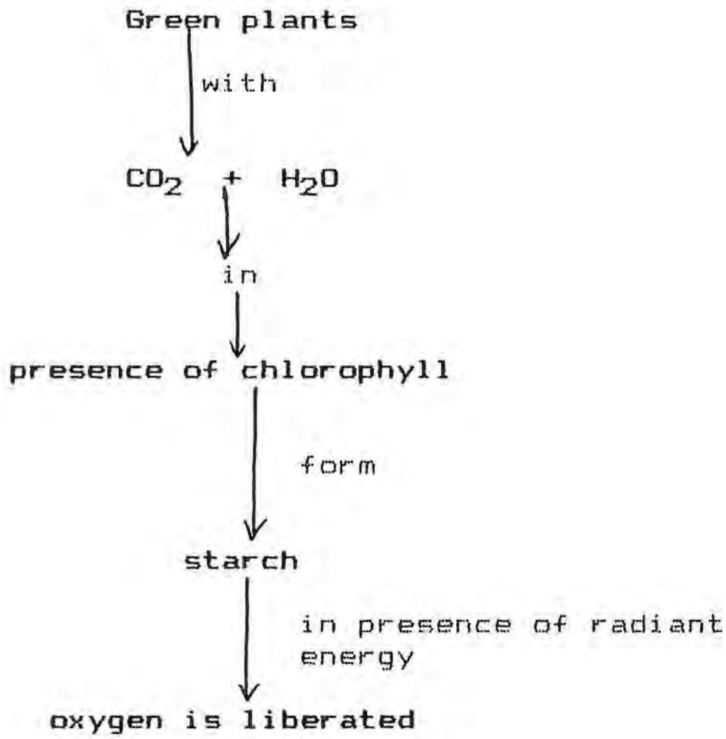


Figure 4

71,4% of the respondents have arranged their concepts and linked them in the following way:-

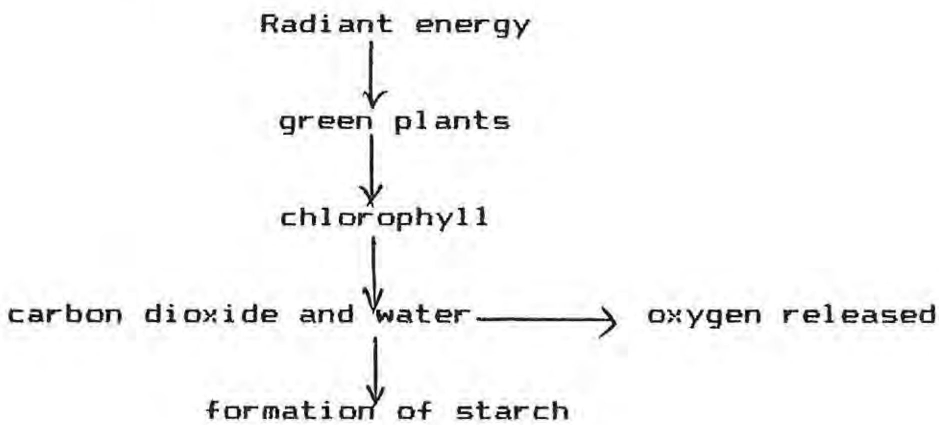


Figure 5

One notices that had there been linking words between the concepts, the concept map would, at least give a reasonable explanation of photosynthesis. This is more so when compared with the concept map of the third group (14,3%) whose concept maps are of the following nature:-

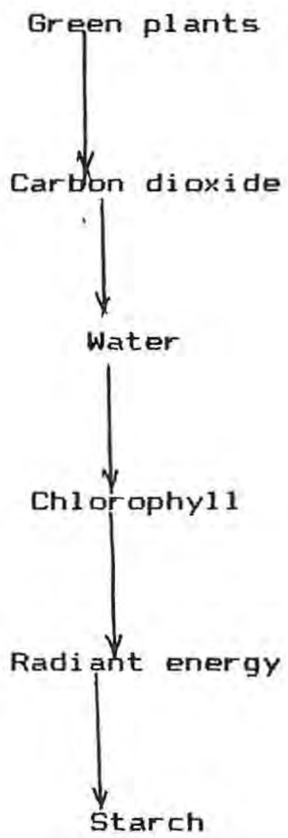


Figure 6

Concept Map 2

Three categories can be distinguished from the students' responses:-

Category I

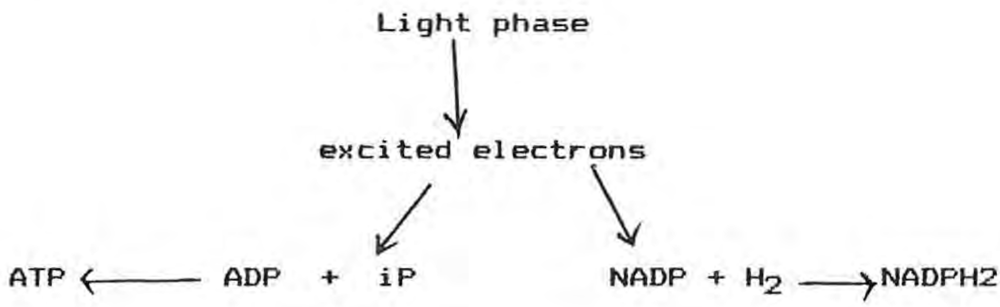


Figure 7

Although there are no linking words, the concept map shows a relationship of the concepts, which indicates some understanding of the light phase.

Category 2:

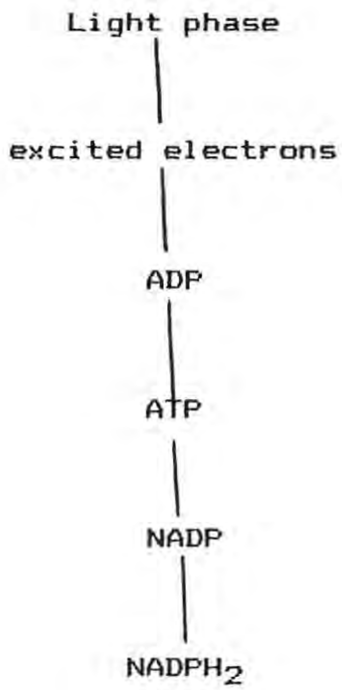


Figure 8

The relationship between some concepts is not correct.

Category 3:

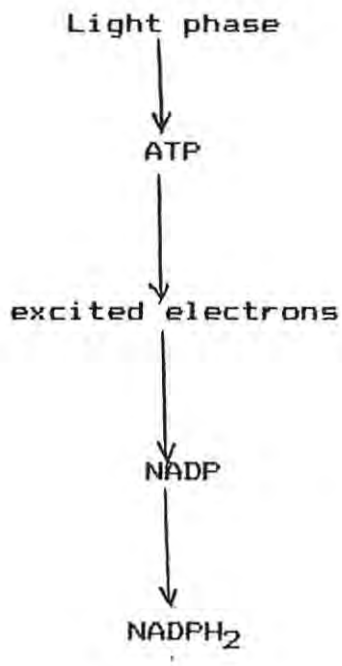


Figure 9

Concept Map 3:

Almost all responses to this test gave a vague map of the following nature:-

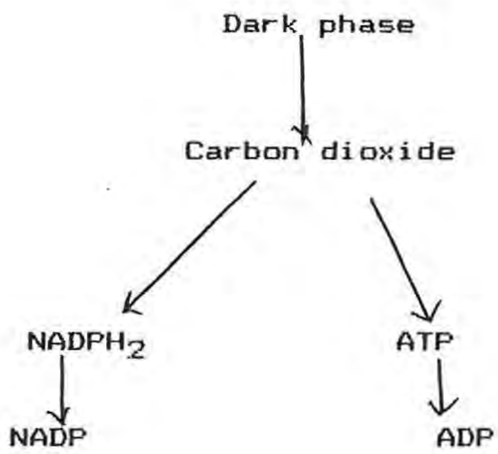


Figure 10

Comment:

On the whole, what becomes apparent from this, is that the respondents had not yet mastered the concept-mapping skill as a tool they could use. These responses, when compared with those of the Bell concept tests do not reflect whether the students understand photosynthesis or not.

Final Discussion

The second language tutoring and the written examinations only may not give a fair reflection of the students' understanding. This has been shown by this concept test. Most of the respondents did not indicate that they understood the relationship of photosynthesis to ecology. Further probing by interview revealed that the students actually do relate these.

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

5.1 FINDINGS

5.1.1 Introduction

This study has brought to the fore the fact that the poor results in the biochemistry section of biology can be related to the inadequate teaching of this section. It has also shown that the college students have difficulty in their college biology classes because of a lack of a good science background, an inability to think critically, a negative or indifferent attitude to science and a lack of self-discipline and study skills. These factors were also seen to affect college freshmen whom Uno (1988) was teaching.

5.1.2 Teachers' Qualifications

Of the interviewed teachers/lecturers, 32% are not qualified to teach biology at Standard 10 level, and 28% are not qualified teachers at all. (See Table 3.10, p. 46). In the whole Transkei 48,2% of the biology teachers are not qualified to teach biology in Standard 10.

As has been stated earlier on, some of the teachers did not study biochemistry in school, and may therefore have less scientific background than is required for teaching the present matric biology syllabus. The tendency according to Hofstein *et al* (1986), is that the teachers like those are less flexible and more dependent on text books.

5.1.3 Students' Attitude towards biochemistry and how it is taught

Although most of the students interviewed advocated that they like biology, this 'liking' was found to be correlated with their achievement in the subject, rather than their actual interest in and commitment to the subject. Many students also believe that biology in general, and biochemistry in particular, has nothing to do with their lives. This negative attitude towards biochemistry affects both the choice of the subject to study and the mastery of the content.

Hofstein *et al* (1986) are of the opinion that the students' perception of science is influenced by the following:-

* the image of the teacher and his or her behaviour.

* the curriculum implemented in the school.

* the national culture and current conditions.

* the teacher-preparation and continuing programmes for the teacher-growth.

These perceptions have often appeared in the student-teachers' responses. Some of the interviewed student-teachers have shown a lack of confidence in the way their teachers teach biochemistry. The failure of the teachers to present biochemistry in such a way that the students understand and appreciate it, has affected their attitude to it.

The students also felt that biochemistry is made more abstract by being isolated from the other aspects of biology and by not being applied to real-life situations. Students should also be given a chance to synthesise basic content into some type of structure reflective of his or her personal needs. Then biology and/or biochemistry will have a meaning to them.

5.1.4 Lack of correlation about the difficult biochemistry topics between the teachers and the student-teachers

It was interesting to note that some of the topics that the biology teachers felt were difficult for the students, were in fact rated easy by the student-teachers.

Photosynthesis, for example, was rated high in the list of difficult topics by the teachers. On the other hand the student-teachers rated it as one of the easiest topics.

A concept-test given to some of the student-teacher respondents, though, showed that most of them do not really understand photosynthesis as a process. All they could narrate was a definition of the process, without actually understanding what it involves, and its role in ecology.

The biology teachers could have noticed these short-comings in the students' understanding of photosynthesis, for them to rate it high in the list of difficult topics.

The researcher was concerned to learn that most of the interviewed biology teachers (both high school and college), were under the impression that biochemistry embraces only the biological compounds and the nucleic acids. If the teachers have this narrow understanding about what is covered in biochemistry, then it is possible for them to transfer it to the students and the student-teachers.

5.1.5 <u>Reasons for the students' poor performance in biochemistry</u>

Both the teachers and the student-teachers felt that the difficulty in understanding most of the biochemistry concepts is caused by a lack in chemistry background. Coupled with this is the lack of facilities for doing practical work which would help even those with less background in chemistry.

In the past five years there has been a rapid proliferation of high schools in Transkei, and consequently a high rise in enrolment. Science-teacher production, though, has not risen concomitantly. This has forced these schools to employ unqualified science teachers. Under these circumstances science teachers are included to employ the lecture method, rather than the methods involving student-material interactions. This also results in ineffective teaching of biology, which, in turn results in the students' negative attitude towards the subject.

In an attempt to verify the claim by the respondents that the pupils in the junior secondary schools do not receive appropriate chemistry background, the researcher got access to Standard 7 external scripts for general science. This paper combines questions for biology, chemistry and physics. The scripts were chosen randomly from as many different examination centres as was possible. The main focus was on the marks obtained by the candidates in the three questions on chemistry, compared with the overall marks obtained for the whole paper. Altogether 80 sets of marks were used. With these raw scores, the researcher attempted to find the correlation between the students' performance in chemistry and the other section of the paper. For the scores and the tables see appendix III.

The Pearsons' Product moment correlation coefficient (r) is, according to Behr (1983), the most widely used method for getting both the direction and the strength of a correlation. By using the formula

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]\}}$$

the product-moment correlation co-efficient r = 0,74.

Calculating the standard error, SEr using the formula

$$SEr = \frac{1 - r^2}{\sqrt{N}}$$

$$= \frac{1 - (0,74)^2}{\sqrt{80}}$$

$$= 0,05$$

We can therefore either be 95% sure that the population - r lies between 0,74 ± 2(0,05); which is between 0,64 and 0,84; or be 99,7% sure that it lies between 0,74 ± 2(0,05); which is between 0,59 and 0,89. Even the lowest of these four extremes, namely 0,59 is significant at 0,01 level.

This means that there is a strong positive relationship between the chemistry scores and the "other" scores. If a candidate's 'other' score is high then his chemistry score is very likely also to be relatively high.

A t-test of significance of difference between means, calculated using the formula

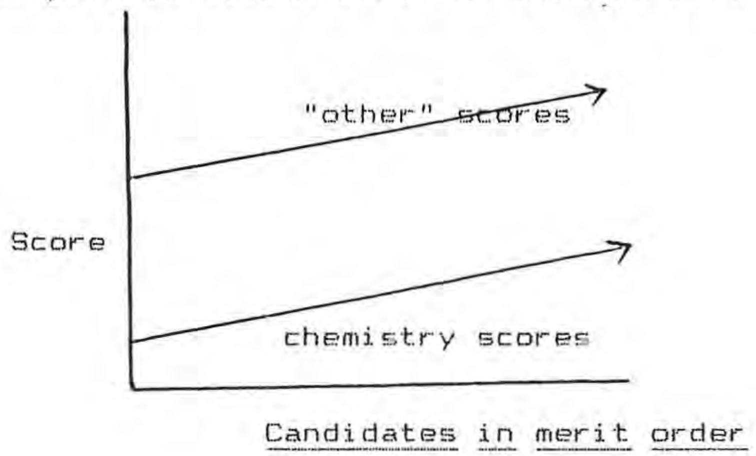
$$t = \frac{\epsilon d}{\sqrt{\frac{N\epsilon d^2 - (\epsilon d)^2}{N-1}}}$$

yields a value of t = 11,9. From this the conclusion is that the difference between the means (41,62% for "other" scores and 28,39% for chemistry scores) is highly significant. This is concluded with a confidence that is greater than 99,9%.

This can be interpreted as follows:-

The candidates have achieved higher scores for "other" sections than for the chemistry section, but that the chemistry scores have followed the same trend as the "other" scores at a significantly different level. Candidates who have done well in the "other" section have also done well in "chemistry" relative to their peers.

A simplistic illustration of this is as follows:-



5.1.6 Suggestions for Improvement

Teachers suggested a need for an improvement in the teaching strategies when presenting biochemistry. Because of its nature, and the 'students' attitude towards it, biochemistry cannot be taught like the other less abstract sections of biology. Less qualified teachers should be offered more opportunities to attend in-service courses.

5.2 Recommendations

From the above findings, the researcher has some recommendations to make, as an attempt to improve the teaching of biochemistry in Transkei schools.

5.2.1 The Teaching Strategies

The Teachers' Role

The challenge facing all science teachers today is the organisation of instruction in such a way as to facilitate learning for the majority of students. In situations where facilities are limited and classes are big, teachers tend to use lecture method, in which the teachers and students interact through talking and writing on the chalkboard. This is the case in Transkei schools.

Okebukola and Ogunniyi (1986) found out that, contrary to the belief that African students "can only thrive in an autocratic environment", the African child can give full expression of his talent if the teacher exerts more of the indirect verbal influence, especially in science classes. The teacher should make an effort, therefore, to develop a classroom climate in which the students feel free to ask questions and state opinions in order to increase their understanding of the learning task. Science involves question asking, curiosity and development of a searching mind.

It is important that teachers are confident in their understanding of concepts they are to teach. They can then contribute to the improvement of the teaching of biology. Their awareness of the students' misconceptions could contribute to the improvement of both their teaching and student understanding. In order to improve their teaching, teachers need to be encouraged to use teaching strategies which research findings have shown to be effective. These strategies place an emphasis on the active involvement of the student in his own learning. Examples of these strategies include the use and development of concept maps and the construction and use of work sheets. Teachers can be exposed to new or alternative teaching strategies by attending in-service courses, workshops, conferences and conventions. The Transkie college lecturers, in particular, should be encouraged to attend these, in order that they can implement these "new" teaching strategies in the education of the student-teachers.

Alternative teaching strategies do not necessarily always require "facilities". A start could be made by using simple strategies. A practical way to teach students how to think about concepts suggested by Dantonio (1987) involves starting a lesson by stimulating a discussion. A conceptual discussion, according to him is a:

> continuous focussed interaction among learners about a concept. Conceptual discussions provide opportunities for students to process information for themselves to reinforce previously-learned facts, to share common experiences and to clarify and deepen their understanding of science concepts.
>
> Dantonio (1987). p 46.

The teacher should, therefore, facilitate such concrete discussions by guiding the students to appreciate the critical characteristics of the concept, by asking appropriate follow-up questions. This approach/ strategy, does however, require an adequate understanding of the topic on the part of the teacher. In Transkei, this could be a problem for teachers who are under- or unqualified.

It is not sufficient for the teacher to identify misconceptions held by students, they must also have the strategies to help students develop the scientifically acceptable conception. Lawson (1988) is of the opinion that for students to overcome prior misconceptions, they must become aware of the scientific conceptions as well as their own alternative conceptions. They must be able to logically see how the evidence supports the scientific conceptions and contradicts the misconception.

In addition, the teachers and college lecturers should encourage students and teacher-trainees to construct models. An example is the model of a DNA molecule, to demonstrate the structure of DNA, its replication, transcription and protein synthesis. Models, when used as teaching aids, help students to understand processes where they must assume the existence of some property or mechanism that cannot be directly verified by experiment. (Schrader, 1985).

5.2.2. Language

Strevens (1976) identifies the following assumptions made in the practice of science education :-

* the learner is a member of the same culture as those within which the studies of science education were prepared.

* the teacher and learner have as their common mother tongue the language in which the science is being taught.

For Transkeian learners, these assumptions lead to shortcomings in the learning and teaching of science, since science is taught in English, which in most cases is not a mother tongue of either the teacher or the science learner. Rarely are the learners taught by a science teacher whose mother tongue is English.

A major problem is the level of competence in English of both the teachers and the pupils. In many cases English is used as a medium of communication only in the teaching situation, and does not form part of the pupils' everyday life. As a result they get no opportunities to practise or extend their English language skills.

Colleges of education do recognise the problem and encourage student-teachers to study the English communication skills throughout the three years of teacher-training. The carryover of these skills, however, in the learning and teaching of science, is, unfortunately limited. Students have difficulty expressing the science concepts in English.

Expatriate recruitment into Transkei to help with science teaching has not made the situation any better. Some of these teachers have limited English ability and an unfamiliar accent which the students have to get used to. Deficient English ability, according to Wong (1985), handicaps meaningful learning for students, and effective teaching by the teacher.

The problems of teaching and learning science in a foreign language is worsened by the fact that there is a lack in the learner's language of words equivalent to the English science words. This poses difficulties for the learners, since they cannot appeal to translation into their mother tongue for the resolution of doubt. If the science subject is taught by an English-speaking teacher, he must watch for the unwitting presence in his teaching of ideas which may be baffling to the learners, although self-evident to him.

In the colleges of education a solution to this could be the teaching of English for science, where special emphasis is placed on the English needed to express and explain science concepts. Not only is there a need to understand the role of language in developing science concepts, but also to recognise the confusion that the use of certain terms can have where the scientific and everyday usage may be different.

5.2.3 Overloaded Syllabus

The biology syllabus seems to be overloaded and to place considerable emphasis on words, terms or definitions as a principal ingredient of the science that a student encounters and that he is expected to master. This emphasis may separate concepts from their meaning, and cause students to memorise the subject matter without grasping the underlying concepts. To this problem, Wandersee (1985) suggests that the teachers should try to teach without overloading the student's conceptual frameworks with unrelated information. Details that are inessential for the understanding of general principles should be omitted. However, additional relevant information may greatly assist in the understanding of science concepts.

When one considers the students' difficulties in understanding the concepts, like in the role of photosynthesis for instance, the language used and the fact that it is taught by unqualified teachers in most cases, one wonders if the biology syllabus should not be shortened. Fewer topics should be included in the syllabus, in the hope that they will be studied with understanding.

5.2.4 The Biology Text Books

School text books play a very important role in the teaching of biology in the schools. For most of the less-qualified biology teachers the text book becomes their main teaching resource.

Cliburn (1987) an anatomy and physiology teacher wanted to choose the best text book that would benefit his students most. In the end his choice was compromise, because of the lack of alternatives. No text book was much different from its competitors when he judged them against the factors he used during review and selection.

The currently available text books for Transkei biology teachers present the same problems as described above. Because of the race by publishers to get books in the market, and the panic by the teachers caused by a change in the syllabus, the books have both printing errors and factual mistakes.

A look through some of the popularly used texts reveals that they either delve too deeply into the topics, which could confuse students and unqualified teachers or they take a lot for granted and therefore are too superficial in their explanation of the concepts. From this, it is evident that the text books do not accurately guide the teachers. It is almost as though three things are necessary, namely:

- an expanded guide for the interpretation of the syllabus to be produced by the Department of Education.

- a choice of competent and accurate text books for the students.

- a teacher's version of the text book which suggests practical work, exercises, and work sheets.

This is the pattern in many text books from overseas.

The Transkei Department of Education recommends a list of text books, through subject committees. Teachers are then supposed to choose text books from the recommended lists. The problem here is that teachers have little expertise in the criteria to be used in the selection of text books. The problem is greatly increased when selection is to be done by an unqualified teacher. The tendency is then to choose text books they had used as students. McInerney (1986) suggests that teachers must show a willingness to accept a change in text books that will concentrate on major concept inquiry, and on instruction that will illustrate personal and social implications of science.

In Transkei colleges at present, the content of the teacher training course is based on the Standards 8, 9 and 10 biology syllabus. The lecturers and students therefore use the same school text books. The researcher feels that the college texts should stress concepts and processes to encourage college lecturers to modify their teaching strategies, and thus start the prospective biology teachers on a path of thinking, investigating and understanding. It is to be hoped that the teachers' confidence in using a variety of teaching techniques or strategies could lead to a call for alternative and more appropriate text books.

In colleges of education, lecturers are responsible for producing a new generation of biology teachers who are trained in methods and concepts of science. College text books should not be encyclopaedic, lest some ambitious students should attempt to memorise the mass of information to prepare for the examination that rewards memorisation. (Wivagg, 1987).

It is recommended that an elementary text book for the University Biology Course One, could be used in the last year of the teacher training course. It must cover most of the work that the prospective teacher will be teaching, but at the same time put him at a level above that of the pupils he will be teaching. Prospective biology teachers must also be trained to evaluate text books properly so that they can make appropriate choices to meet the needs of their pupils. This may be difficult since teachers need some teaching experience before being able to do this effectively, and may need to attend an in-service course.

5.2.5 Pre-service Training

Ideally, the student-teachers who major in biology should be those who are knowledgeable of senior secondary biology. In reality the biology major students have passed with a D on average. The role of a college of education is three-fold. Student-teachers have to be taught biology content, teaching strategies and approaches and to build their self-confidence, to enable them to teach pupils in the classroom.

The college lecturers should work towards developing good study habits in the student-teachers. Uno (1988) suggests that students need to be trained to recognise what is important to learn and how to learn it. Examinations should test the students' ability to use critical thinking skills. Students require the understanding of the concepts rather than just the recognition of facts.

Rather than copying notes, college students should be encouraged to get information for themselves, make the notes focusing on ideas, putting lecturers' notes into their own words. They should also write down questions they may have about the lectures.

Uno (1988) advocates self-discipline in the college students, since through it the students learn to pace their studying so that they do not have to cram for examinations. Lecturers should give students cumulative examinations that require application of new concepts to previously-learned information.

In the light of this study, colleges of education should focus on the introduction of practical work, and use of teaching strategies which will improve the student-teachers' confidence.

5.2.6 In-service Training

Biology, as a subject, in the curriculum, is changing more rapidly than ever. It requires a constant effort to teach modern biology. A professional biology teacher should attend workshop meetings, and belong to organisations that promote biology education. He or she should often be working towards an advanced degree. In Transkei, most of the biology teachers studying towards a degree are not studying biology, so they are not upgrading their knowledge in the subject. The University of Transkei does not offer part-time studying of the science subjects. The situation is made even more critical because the teachers have difficulties in obtaining study leave with pay.

Teachers should attend in-service courses to keep abreast with the new topics that are added to the syllabus. In-service courses can be used to enhance the use of alternative teaching strategies. Ideally there should be a feedback on a suggested technique so as to try to resolve any problems that might be encountered by teachers. In reality, this is difficult to achieve, since new teachers attend the courses every year.

It is strongly recommended that college lecturers be allowed to attend in-service courses, seminars and workshops in order to improve their teaching of biology.

5.3 Conclusion

The aim of this study was to identify the problems in the teaching and learning of biochemistry, and the areas of biochemistry which the students find particularly difficult to understand, and, to some extent, the study was able to produce some results in this regard.

An interesting finding was the conflict between the responses of the teachers/lecturers and those of the student-teachers about the areas of biochemistry that students find difficult to understand. The student-teachers regarded photosynthesis as a concept that is easy to understand, whereas the teachers/lecturers felt that students do not understand photosynthesis very well.

The findings of the concept-test on photosynthesis, though, seemed to favour the teachers' opinion. Quite a number of the respondents showed a very poor understanding of the concept.

The situation in the schools with regard to the lack of facilities, students being taught by under- or unqualified teachers and the language problems was found to contribute to the poor teaching of biochemistry.

The situation in the schools and colleges cannot change overnight. Adoption of some of the new teaching strategies which do not necessarily need the use of laboratory equipment, could improve the situation.

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A QUESTIONNAIRE TO BE ADMINSITERED TO THE COMPLETING BIOLOGY STUDENTS IN THE SECONDARY TEACHERS DIPLOMA (STD)

This questionnaire is an attempt to identify the areas in the biochemistry section of biology which students find particularly difficult. You are therefore asked to be free and frank in your answers. You are asked not to discuss the questionnaire before answering it. Any information you give will be treated as confidential.

The following is the list of biochemistry topics as laid down by the new syllabus.

1. Chemical composition of protoplasm
2. Relavant functions of water and proteins
3. Nucleic acids
4. Protein synthesis and gene mutation
5. Biological compounds and nutrients - water, macro- and micronutrients, organic compounds - carbohydrates, lipids, proteins, vitamins
6. Enzymes and co-enzymes
7. Photosynthesis
8. Cellular respiration
9. Chemical processes of digestion

SECTION A

GENERAL INFORMATION

1. Name of the College: ....

2. Age of student:

Below 16
16 - 20
Above 20

3. Sex:

Male
Female

4. Symbol obtained in Standard 10 Biology:

A - B
C D
E - F
Below F

2. ....
3. ....

14. What, do you think, makes the 3 areas above difficult to understand?

....
....
....

15. Give 3 possible reasons why biochemistry tends to be more difficult to understand than the other sections of biology:

1. ....
2. ....
3. ....

16. Suggest 3 ways that can help students to understand biochemistry.

1. ....
2. ....
3. ....

THANK YOU.

APPENDIX IB

A QUESTIONNAIRE TO THE TEACHERS/LECTURERS OF BIOLOGY IN THE SENIOR CERTIFICATE AND/OR SECONDARY TEACHERS DIPLOMA

This questionnaire is an attempt to identify the students' problem areas in the biochemistry section of the matric biology syllabus. Your help as a biology teacher is humbly requested. The information you give will be treated as confidential. So, feel free to answer frankly and honestly.

The following is a list of biochemistry topics as laid down by the new syllabus:

1. Chemical composition of protoplasm
2. Relevant functions of water and proteins
3. Nucleic acids
4. Protein synthesis and gene mutation
5. Biological compounds, e.g. carbohydrates, lipids, proteins and vitamins
6. Enzymes and co-enzymes
7. Photosynthesis
8. Cellular respiration
9. Chemical processes of digestion.

SECTION A

GENERAL INFORMATION

1. Name of School/College: ....

2. Teacher's Qualifications

2.1 Academic: ....

2.2 Professional: ....

3. Highest standard in which biology was passed: ....

4. Teaching Experience in Years

0 - 5
5 - 10
10 - 15
More than 15

5. Experience as a biology teacher in years:

0 - 5
5 - 10
10 - 15
More than 15

6. Are you involved in the marking of biology, either in standard 10 or in the college?

YES	NO

SECTION B

7. Have you attended any inservice courses for biology that deal with biochemistry?

YES	NO

8. If your answer in 7 is YES, did you find the course helpful?

YES	NO

9. If your answer in 7 is NO, what is the reason?
....

10. Do you feel adequately qualified to teach biochemistry?

YES	NO

11. If not, why not? ....
....

12. Do you feel that there is too much biochemistry in the biology syllabus?

YES	NO

13. If YES, what suggestion do you have to solve this?
....

14. Do you find it possible to perform most of the experiments in biochemistry?

YES	NO

15. If not, what are the reasons?
1. ....
2. ....
3. ....

16. Why do students perform as badly in biochemistry as they do? Give 3 reasons
1. ....

2. ....
3. ....

17. Identify any 3 areas in biochemistry in which you find students particularly poor.

1. ....
2. ....
3. ....

18. Identify any 3 areas which, in your opinion, students find easier to understand.

1. ....
2. ....
3. ....

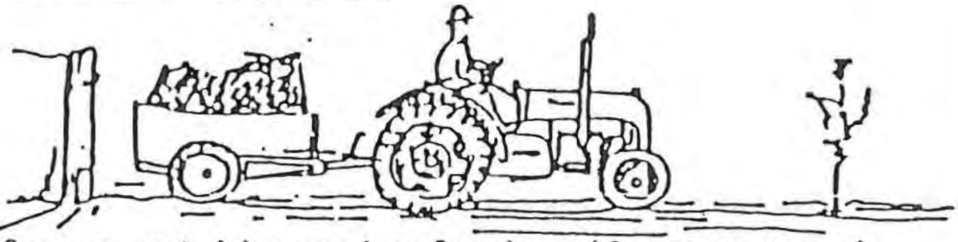
19. Suggest 3 ways in which the students' performance in biochemistry can be improved.

1. ....
2. ....
3. ....

THANK YOU.

Can you please answer the following questions:

Question 1 Hay-today



A farmer cut his meadow for hay (feeding grass). He noticed that the grass he cut was green, but the stalks left were yellow.
How do you explain this?

....

....

....

....

....

Question 2 Villain

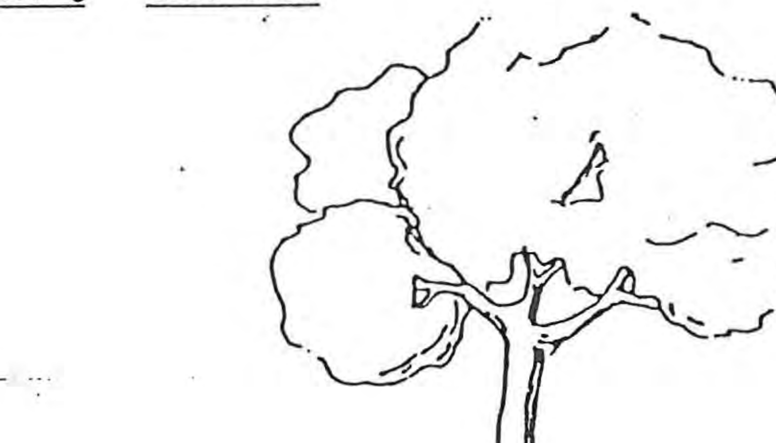
In a science fiction book, a villain (wrong-doer) threatens to spray the countryside with a chemical that destroys chlorophyll (the green substance in plants)
What effect will this have on plant life? Explain your answer as fully as you can.

....

....

....
....
....
....
....

Question 3 Grow Tree



A small tree is planted in a meadow. After 20 years it has grown into a big tree, weighing 250 kg more than when it was planted.

Where do the extra 250 kg come from? Explain your answer as fully as you can.

....
....
....
....

PHOTOSYNTHESIS

ARRANGE THE FOLLOWING CONCEPTS IN THE CORRECT ORDER AND WRITE 3 SHORT PARAGRAPHS, TO SHOW THAT YOU UNDERSTAND HOW THE CONCEPTS CAN BE LINKED. (YOU CAN ALSO LINK THE CONCEPTS IN A CONCEPT MAP.)

1. Green plants, oxygen, starch, carbon dioxide, radiant energy, chlorophyll, water,

2. Light phase, excited electrons, NADP, $NADPH_2$, ADP, ATP.

3. Dark phase, $NADPH_2$, NADP, Carbon dioxide, ATP, ADP.

ENZYMES and CO-ENZYMES

Enzymes, chemical change, catalysts, metabolism, activation energy, active sites, enzyme-substrate complex.

APPENDIX III

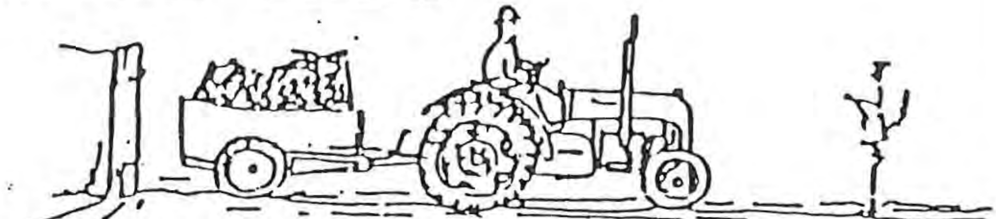
Biochem. Total	Biochem. Percent	"Other" Total	"Other" Percent	X	Y	X sqd	Y sqd	XY	d=Y-X	d s
55	100	245	100	10	10					
10	18.18	17	6.94	1.82	0.69	3.31	0.48	1.26	-1.12	1.
0	0.00	41	16.73	0.00	1.67	0.00	2.80	0.00	1.67	2.
4	7.27	46	18.78	0.73	1.88	0.53	3.53	1.37	1.15	1.
10	18.18	38	15.51	1.82	1.55	3.31	2.41	2.82	-0.27	0.
6	10.91	44	17.96	1.09	1.80	1.19	3.23	1.96	0.71	0.
7	12.73	47	19.18	1.27	1.92	1.62	3.68	2.44	0.65	0.
10	18.18	45	18.37	1.82	1.84	3.31	3.37	3.34	0.02	0.
11	20.00	53	21.63	2.00	2.16	4.00	4.68	4.33	0.16	0.
7	12.73	57	23.27	1.27	2.33	1.62	5.41	2.96	1.05	1.1
12	21.82	60	24.49	2.18	2.45	4.76	6.00	5.34	0.27	0.
7	12.73	63	25.71	1.27	2.57	1.62	6.61	3.27	1.30	1.6
11	20.00	60	24.49	2.00	2.45	4.00	6.00	4.90	0.45	0.2
12	21.82	61	24.90	2.18	2.49	4.76	6.20	5.43	0.31 →	0.0
2	3.64	71	28.98	0.36	2.90	0.13	8.40	1.05	2.53	6.4
10	18.18	66	26.94	1.82	2.69	3.31	7.26	4.90	0.88	0.7
14	25.45	65	26.53	2.55	2.65	6.48	7.04	6.75	0.11	0.0
8	14.55	70	28.57	1.45	2.86	2.12	8.16	4.16	1.40	1.9
3	5.45	79	32.24	0.55	3.22	0.30	10.40	1.76	2.68	7.1
10	18.18	75	30.61	1.82	3.06	3.31	9.37	5.57	1.24	1.5
15	27.27	75	30.61	2.73	3.06	7.44	9.37	8.35	0.33	0.1
18	32.73	73	29.80	3.27	2.98	10.71	8.88	9.75	-0.29	0.0
9	16.36	84	34.29	1.64	3.43	2.68	11.76	5.61	1.79	3.2
11	20.00	84	34.29	2.00	3.43	4.00	11.76	6.86	1.43	2.0
6	10.91	89	36.33	1.09	3.63	1.19	13.20	3.96	2.54	6.4
15	27.27	84	34.29	2.73	3.43	7.44	11.76	9.35	0.70	0.4
16	29.09	79	32.24	2.91	3.22	8.46	10.40	9.38	0.32	0.1
10	18.18	89	36.33	1.82	3.63	3.31	13.20	6.60	1.81	3.2
13	23.64	81	33.06	2.36	3.31	5.59	10.93	7.81	0.94	0.8
7	12.73	93	37.96	1.27	3.80	1.62	14.41	4.83	2.52	6.3
11	20.00	92	37.55	2.00	3.76	4.00	14.10	7.51	1.76	3.0
17	30.91	86	35.10	3.09	3.51	9.55	12.32	10.85	0.42	0.1
15	27.27	88	35.92	2.73	3.59	7.44	12.90	9.80	0.86	0.7
17	30.91	86	35.10	3.09	3.51	9.55	12.32	10.85	0.42	0.1
22	40.00	84	34.29	4.00	3.43	16.00	11.76	13.71	-0.57	0.3
12	21.82	95	38.78	2.18	3.88	4.76	15.04	8.46	1.70	2.8
22	40.00	86	35.10	4.00	3.51	16.00	12.32	14.04	-0.49	0.2
9	16.36	100	40.82	1.64	4.08	2.68	16.66	6.68	2.45	5.9
15	27.27	95	38.78	2.73	3.88	7.44	15.04	10.58	1.15	1.3
12	21.82	99	40.41	2.18	4.04	4.76	16.33	8.82	1.86	3.4
11	20.00	100	40.82	2.00	4.08	4.00	16.66	8.16	2.08	4:3
10	18.18	103	42.04	1.82	4.20	3.31	17.67	7.64	2.39	5.6
8	14.55	106	43.27	1.45	4.33	2.12	18.72	6.29	2.87	8.2
22	40.00	95	38.78	4.00	3.88	16.00	15.04	15.51	-0.12	0.0
15	27.27	103	42.04	2.73	4.20	7.44	17.67	[illegible]	[illegible]	[illegible]
12	21.82	106	43.27	2.18	4.33	4.76	18.72	9.44	2.14	4.6
19	34.55	100	40.82	3.45	4.08	11.93	16.66	14.10	0.63	0.3
16	29.09	103	42.04	2.91	4.20	8.46	17.67	12.23	1.29	1.6
15	27.27	110	44.90	2.73	4.49	7.44	20.16	12.24	1.76	3.1
14	25.45	112	45.71	2.55	4.57	6.48	20.90	11.64	2.03	4.1
18	32.73	111	45.31	3.27	4.53	10.71	20.53	14.83	1.26	1.5
13	23.64	116	47.35	2.36	4.73	5.59	22.42	11.19	2.37	5.6
16	29.09	116	47.35	2.91	4.73	8.46	22.42	13.77	1.83	3.3
12	21.82	121	49.39	2.18	4.94	4.76	24.39	10.78	2.76	7.6
22	40.00	112	45.71	4.00	4.57	16.00	20.90	18.27	0.57	0.3
17	30.91	118	48.16	3.09	4.82	9.55	23.20	14.89	1.73	2.9
15	27.27	120	48.98	2.73	4.90	7.44	23.99	13.36	2.17	4.7

16	29.09	120	48.98	2.91	4.90	8.46	23.99	14.25	1.99	3.96
11	20.00	126	51.43	2.00	5.14	4.00	26.45	10.29	3.14	9.88
17	30.91	122	49.80	3.09	4.98	9.55	24.80	15.39	1.89	3.57
21	38.18	119	48.57	3.82	4.86	14.58	23.59	18.55	1.04	1.08
13	23.64	127	51.84	2.36	5.18	5.59	26.87	12.25	2.82	7.95
26	47.27	117	47.76	4.73	4.78	22.35	22.81	22.58	0.05	0.00
11	20.00	132	53.88	2.00	5.39	4.00	29.03	10.78	3.39	11.48
27	49.09	121	49.39	4.91	4.94	24.10	24.39	24.24	0.03	0.00
23	41.82	129	52.65	4.18	5.27	17.49	27.72	22.02	1.08	1.17
29	52.73	126	51.43	5.27	5.14	27.80	26.45	27.12	-0.13	0.02
16	29.09	140	57.14	2.91	5.71	8.46	32.65	16.62	2.81	7.87
22	40.00	137	55.92	4.00	5.59	16.00	31.27	22.37	1.59	2.53
20	36.36	139	56.73	3.64	5.67	13.22	32.19	20.63	2.04	4.15
20	36.36	140	57.14	3.64	5.71	13.22	32.65	20.78	2.08	4.32
20	36.36	145	59.18	3.64	5.92	13.22	35.03	21.52	2.28	5.21
17	30.91	150	61.22	3.09	6.12	9.55	37.48	18.92	3.03	9.19
22	40.00	149	60.82	4.00	6.08	16.00	36.99	24.33	2.08	4.33
29	52.73	145	59.18	5.27	5.92	27.80	35.03	31.21	0.65	0.42
26	47.27	153	62.45	4.73	6.24	22.35	39.00	29.52	1.52	2.30
27	49.09	152	62.04	4.91	6.20	24.10	38.49	30.46	1.29	1.68
36	65.45	149	60.82	6.55	6.08	42.84	36.99	39.81	-0.46	0.22
31	56.36	166	67.76	5.64	6.78	31.77	45.91	38.19	1.14	1.30
26	47.27	172	70.20	4.73	7.02	22.35	49.29	33.19	2.29	5.26
27	49.09	177	72.24	4.91	7.22	24.10	52.19	35.47	2.32	5.36
29	52.73	178	72.65	5.27	7.27	27.80	52.78	38.31	1.99	3.97
32	58.18	183	74.69	5.82	7.47	33.85	55.79	43.46	1.65	2.73
Mean:	28.39		41.62							
Sum:				235.64	345.43	817.85	1612.65	1100.58	109.79	229.34

Correlation coefficient, r = 0.74

Significance of difference between means: t = 11.90

Question 1 Hay-today



A farmer cut his meadow for hay (feeding grass).
He noticed that the grass he cut was green, but
the stalks left were yellow.
How do you explain this?

How do you ...

The grass is green because it has chlorophyll which enables photosynthesis to take place but the stalks were yellow simple because they were not exposed to sunlight so the colour changed to yellow. The photosynthesis could not take place in stalks since they were under the leaves.

(1)

The green colour of the grass on the surface is caused by its exposure to the sun which means chlorophyll is present. The yellow colour underneath it in the stems shows that there is no chlorophyll hence photosynthesis takes place in the presence of sunlight and chlorophyll.

The grass which the farmer cuts was exposed to sunlight so it carry out its photosynthetic functions. the stalks were not exposed to light because grass does not grow as single stalks it is dense therefore the stalks are not expose i.e there is competition for sunlight

The portion cut that is green has more chloroplast because it is exposed to sunlight and photosynthesis takes place in that green part. The stalks are undercovered therefore no or less photosynthesis takes place. (8)

The reason is that the grass was exposed to the sunlight and water evaporates more easily in aerial parts whereas the stalks did not get sunlight for photosynthesis to take place due to the shade of the grass

The grass stalk do not contain Chlorophyll, they only store food in the form of starch. The contain ~~staghtthe~~ strengthing tissues that are lignified and have no chloroplast.

The stalks were yellow because photosynthesis does not take place in the stems of the grass. The other reason for the stalks to be yellow is that the water from the soil is not used efficiently because leaves are not there.

How do you expl...
The stalks were under the grass and didn't have much light and the upper part was directly facing the sun and also not much air was taken by the stalks

The stalks are yellow because there is not more photosynthesis taking place. Water lost through evaporation the cells have lost the chlorophyll which gives the green colour.

The water that usually comes from the ground to the leaves through the xylem vessels has been cut now the water just evaporate and no photosynthesis taking place. and no chlorophyll containing pigments on the leaves

Yellow stalks are caused by too much oxygen produced by from smoke of the cutter (tractor). Stalks left did not get enough sunlight due to its height.

Question 2 Villain

In a science fiction book, a villain (wrong-doer) threatens to spray the countryside with a chemical that destroys chlorophyll (the green substance in plants)

What effect will this have on plant life? Explain your answer as fully as you can.

Plants depend on chlorophyll in order to manufacture their own food through the process of photosynthesis. So plants can fail to manufacture their own food and animals also cannot survive without plants.

Also The plant won't manufacture its own food because chlorophyll is essential for photosynthesis

The plants will use their stored energy until it is all finished or came to an end. After utilisation of energy the plant will be dying enough

The chlorophyll in plants enable to them to manufacture their own food through the process of photosynthe If without chlorophyll we know the photosynthesis is not taking place and therefore the plants will ultimately because they do not manufacture their own food.

If chlorophyll is destroyed photosynthesis will not take place place thus the plants will not be able to manufacture its own food.

Plants will used the stored energy in the guard cells.

If the chlorophyll has been damage the whole life of a plant will come to a hault. A plant cannot live without ~~photosy~~ chlorophyll, meaning which the spray will destroy all the plants in area for ever.

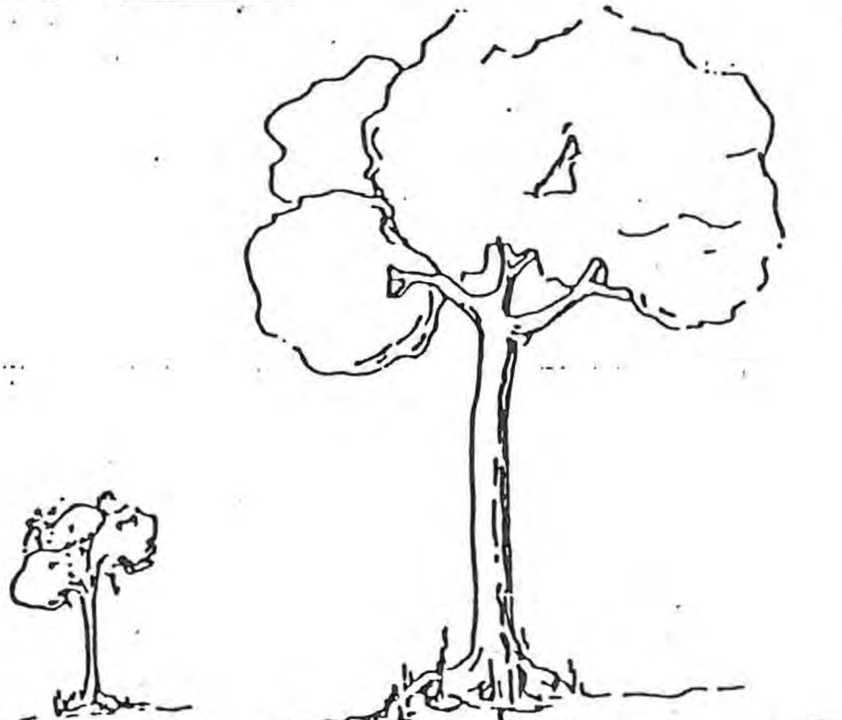
The plants will all die due to the absence of Chlorophyll because if plants do not have Chlorophyll, photosynthesis will not occur.

When the chlorophyll is destroyed plants won't be ~~to~~ able to manufacture ~~th~~ their own food and photosynthesis can take place. Then the plants would die.

The plants will loose the green colour meaning that they cannot manufacture their own food and they will die but due to the fact that these plants still obtain water from the roots they can survive until they obtain back their green colour due to the exposure to sunlight.

On plant life if the chlorophyll is destroyed plant will not be able to manufacture their own food therefore they will die. If that chemical is used it will not only kill the ~~(pla)~~ chlorophyll but it will kill the plant itself.

Question 3 Grow Tree



A small tree is planted in a meadow. After 20 years it has grown into a big tree, weighing 250 kg more than when it was planted.

Where do the extra 250 kg come from? Explain your answer as fully as you can.

The plants absorb water and dissolve mineral salts. It get CO_2 from its surrounding and is able to synthesise it own food with the use of sunlight and chlorophyll. food and water are transported by xylem and phloem to all parts of the plant. Cell are then able to devide mitotically and give rise to the big tree. (1)

The extra 250kg came from the soil. The nutrients reach the tree through the roots. Roots absorb water and mineral salts from the soil and transport them to the stem of the tree.

It has got the extra 250kg from the nutrients that are in the soil, from water and from the sunlight. For a plant to gain extra kg, fertile soil is essential. (2)

The young plant has grown through the process of mitosis i.e. many cells have been added. The big tree absorbs many nutrients and water from the soil.

For a plant to grow bigger it should undergo secondary thickening as a result of Cambium and pericycle in the stem. Cambium rings will be formed and annual rings finally then the weight is increasing yearly as the plant grows in width and length due to primary and secondary thickening

The tissues divide and lignin is added also secondary thickening occurs whereby causing the tree to become wide and big.

As the plant grows, it is fed on the soil with water and mineral salts. The stem grows and more layers are found. The roots also grow and the tree is firm on the ground. The leaves make food by photosynthesis and its taken to all parts of the tree thus causing the tree to grow.

Because of the presence vascular bundles they expand the cortex and expand it. Then vascular bundles form rings which we call annual rings to determine the age of the tree.

As it grow it becomes bigger and strong and have more nutrients which make it stronger. So the extra 250kg come from its strongness, growth and bigness.

At first the growth was inhibited by other plants. After some time these young start break out and are decomposed then the tree gets more nutrients and grow rapidly.