ENHANCING SENIOR SECONDARY SCHOOL STUDENTS' COGNITIVE ACHIEVEMENT IN SELECTED BIOLOGY CONCEPTS USING MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY

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CERTIFICATION

This is to certify that the Thesis:

"ENHANCING SENIOR SECONDARY SCHOOL STUDENTS' COGNITIVE ACHIEVEMENT IN SELECTED BIOLOGY CONCEPTS USING MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY"

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DEDICATION

This thesis is dedicated to the Almighty God, the Ancient of Days, Preserver of men, Ruler over the nations and affairs of men, Eternal, Immortal, Invisible King, the only wise God. My Maker, Husband, Helper, Redeemer and Salvation. Blessed be your glorious name forever.

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ABSTRACT

The ineffectiveness of the strategies traditionally employed by science teachers has been attested to by several researchers. Thus, research in science education has continued to seek for more effective ways of teaching science in general and biology in particular in order to ensure meaningful learning. Therefore, this study examined Senior Secondary School Students' Cognitive Achievement in Selected Biology Concepts using Mercedes Model with Embedded Assessment Strategies. The study adopted pretest-post-test control group, quasi experimental design. From the six education districts (EDs) in Lagos State, two were purposively selected. The two EDs were randomly assigned to experimental and control groups. Three senior secondary schools were randomly selected from each ED. Altogether, a total of six schools in the two selected EDs were involved in the study. Two intact classes (one science and another non-science) were randomly selected from each of the six schools making a total of twelve classes. Five instruments were used. These included: Mercedes Model with Embedded Assessment Strategy in Diffusion (MEASID), Mercedes Model with Embedded Assessment Strategy in Osmosis (MEASIO). Conventional Lesson Plan on Diffusion (COLPOD), Conventional Lesson Plan on Osmosis (COLPO) and Test on Students' Learning Outcomes in Osmosis and Diffusion (TESLOOD). Seven hypotheses were tested at 0.05 level of significance. Data collected were analysed using frequency counts, means, deviation, analysis of covariance, multiple classification analysis. There was significant effect of treatment on students' cognitive achievement on selected biology concepts. Also, subject specialization has a significant effect on the dependent measures. Further, the effect of gender on students' knowledge of the selected biology concept is significant in favour of males. From the findings of this study the Mercedes Model with Embedded Assessment Strategies was effective and noticeably improved students' cognitive achievement. Furthermore, the biology students in the science class performed better than their counterparts in the non-science class. This study also showed that the Mercedes Model with Embedded Strategy was of equal benefit to both male and female students. It was recommended that biology teachers should adopt Mercedes Model with Embedded Assessment Strategy in the teaching of secondary school students.

TABLE OF CONTENT

CHAPTER SIX: RECOMMENDATIONS AND CONCLUSION

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

M. M	-	Mercedes Model
EAS	-	Embedded Assessment Strategy
S^1	-	Mind Stretcher is one of the 13 Embedded Assessment Strategies
S^2	-	Models, Picture and Diagrams
S^3	-	Preposition Generation
S^4	-	This is one of the thirteen strategies of Gallagher which is called laboratory demonstration
S5	-	Laboratory Experiments/Record Observation
MEASID	-	Mercedes Model with Embedded Assessment in Diffusion
MEASIO	-	Mercedes Model with Embedded Assessment in Osmosis
COLPOD	-	Conventional Lesson Plan on Diffusion
COLPO	-	Conventional Lesson Plan on Osmosis
TESLOD	-	Test on Students' Learning Outcome in Osmosis and Diffusion
TIG. MEASIO	-	Teacher's Instructional Guide for Mercedes Model and Embedded Assessment Strategy in Osmosis.
TIG. MEASID	-	Teacher's Instructional Guide for Mercedes Model and Embedded Assessment Strategy in Diffusion
ATL	-	Approaches To Learning

CHAPTER ONE

INTRODUCTION

1.1.0 Background to the Study

During the early years of the 20th century, science education was justified more and more on the basis of its relevance to contemporary life and its contribution to a shared understanding of the world on the part of all members of society (Dewey, 1916). By 1932, however, there was the concern that curriculum developers had gone too far in making the subject matter "relevant" and had forgotten the fundamental reason why science was being studied, which was to provide a broad understanding of the natural world and the way it affected people's personal and social lives (De Boer, 2000).

The Second World War (1939 - 1945) created awareness about the impact of science on man's thinking, social condition as well as political and economic development.
The launching of the Sputnik I, by the USSR in 1957 however, came as a tremendous shock to the West. The Americans wondered why their Scientists were not the first to go into space. Consequently, many western countries started to reconsider the content of the science taught in school and the way in which it was taught.

In the United States of America, huge investments went into large scale curriculum development in science with projects such as the Physical Science Study Committee (PSSC), the Chemical Bond Approach (CBA), Chemical Education Materials Study (CHEMSTUDY), and the Biology Sciences Curriculum Study (BSCS) in 1959. (Hurd, 1971).

England followed in the 1960s with more than a dozen curriculum development projects sponsored by the Nuffield Foundation in Physics, Chemistry, Biology and Integrated Science. Many other countries such as France, Germany, Sweden, Canada, and Australia joined the move towards curriculum development, some adapting the ideas and others developing their own.

In Nigeria, science teaching can be traced back to 1859. However, the pace of science education development between the periods of 1883 to 1930 was retarded to some extent by the insufficient time devoted to science teaching on the school timetable, inadequate financing of science education, lack of suitably qualified science teachers, absence of science textbooks in schools, and lack of laboratory facilities and science equipment in schools. (Ogunleye, 1999)

In view of the difficulty in getting trained science teachers as well as obtain effective resources for science teaching, there was lack of uniformity in science teaching. Some schools offered General Science, which comprised of biology, chemistry and physics leading to the school certificate level while in other schools, general science was taught at the lower forms and in the senior classes, students could specialize in biology, chemistry and or physics.

By the mid 1950s, General Science in Nigeria schools began to experience a "failure" as an approach to science teaching. Most Nigerian schools had to return to the science education method with a two-tier approach. General science was taught during the first two years to every student in a five-year secondary education programme. Students were allowed to specialize during the last two years of the five years secondary school programme. Once this method was accepted, science teaching involving laboratory work became pertinent to meet the practical requirements of the single science subjects at the school certificate.

To this end, Okeke (1983), reported that the secondary school biology syllabus used in Nigeria under the British Colonial era had no stated objectives, general or specific. According to her, it was an examination syllabus rather than a teaching syllabus. It was knowledge for knowledge's sake rather than knowledge to solve practical problems. Biology was reduced to a descriptive subject, which was taught through the use of the lecture method. There was also no emphasis on laboratory work and acquisition of scientific skills.

On the 30th November, 1957 the Science Teachers' Association of Nigeria (STAN). was inaugurated . The successful introduction of integrated science into the junior forms by this association resulted in a shift in the objectives and methods of science teaching in our secondary schools. The STAN integrated science project was concerned with the teaching of science through inquiry and discovery approaches (STAN 1973).

In spite of this, the curriculum in science education came under sharp criticism as summarized in the words of Wenike Briggs: "Perhaps it is only in these last few years that we have become conscious of the fact that we have been educating boys and girls for an age that has already passed us by we will need some drastic rethinking about the content of training we give them" (Common Wealth Education Conference, 1968).

In the same vein, Cookey (1970) criticized the Nigerian educational system as follows: Right from the start, the pupils work with an eye on the syllabus for the First School Leaving Certificate. Past question papers are religiously plodded through and model answers memorized. Not much thought is given to the problem of equipping the pupils for life outside the classroom. Where science is taught, the work done is often only theoretical and severely limited by the syllabus of the examination being prepared for. The children get hold of large chunks of unrelated Knowledge which they cannot digest. This type of education is certainly not what is needed in a young country like ours (page 14).

Similarly, Fafunwa (1981) describes the system of education thus: 'Our present system is like Joseph's multi-colour dress with several patches here and there and with threads running in all directions. There are many routes and too many dead ends within the system'.

As a response to all these criticisms, the Federal Government of Nigeria through the Nigerian Education Research Council (NERC) now Nigeria Educational Research and Development Council (NERDC) organized a National Curriculum Conference in September 1969 with a mandate to review the existing education system, identify what may be called a National Philosophy of Education and set up guidelines for curriculum development.

The goals identified for secondary education according to the National Policy on Education (NPE) (1981) included equipping students to live effectively in our modern age of science and technology and diversifying the secondary school curriculum to cater for differences in talents, opportunities and roles open to students after their secondary school course. On the whole, the emphasis was on utility of knowledge for effective functioning in the society. The basic objectives of the biology curriculum are to prepare pupils to acquire adequate laboratory and field skills in biology; meaningful and relevant knowledge in biology; ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture and reasonable and functional scientific attitude. The content and implementation of the curriculum emphasize field studies, guided-discovery, laboratory techniques and skills as well as conceptual thinking. (NFM, 1985).

In the forefront of reforms in science are the Science Teachers Association of Nigeria (STAN), Comparative Study and Adaptation Center (CESAC), Nigeria Education Research Council (NERC), National Teachers' Institute (NTI) and the West African Examinations Council (WAEC) which reviews and incorporates changes in the curriculum into the examination syllabus.

The activities of STAN and CESAC in improving biology education were further supported by the National Policy on Education, which was first published in 1977. This policy at the secondary school level emphasized the preparation of the students for useful living within the society and for higher education. The curriculum emphasized equipping students to live effectively in our modern age of science and technology. The revised edition of the National Policy on Education (1981) laid greater emphasis on the role of science in national development and reasonable and functional scientific attitude. The content and context of the curriculum emphasize field studies, guided-discovery, laboratory techniques and skills as well as conceptual thinking.

With the introduction of the National Policy on Education (FME, 2004) 6 - 3 - 3 - 4 system; in which secondary education was broken to three years junior secondary and three years senior secondary brought about the review of the 'O' level biology syllabus. STAN produced a biology curriculum for the senior secondary school. This new curriculum aimed at involving students in actual laboratory techniques and skills. The introduction of the new curriculum calls for new teaching methods and new evaluation techniques. This period thus saw a large investment in science curriculum reforms.

However, the Report on Education Sector Situation Analysis 2006/2007 in which the former Minister of Education, Obiageli Ezekwesili rightly said that "the decay in the education sector had assumed an unimaginable low dimension" at all the levels of education, be it basic, senior secondary or tertiary, the product/ output is low. This calls for a serious concern and consideration.

Also, in the report of comparison of 22 Sub-Saharan and North African countries in the Monitoring of Learning Achievement (MLA) project of the 1990s, Nigeria primary school pupils were the lowest with the national mean score of 30% compared with the highest score of 70% by Tunisia and a median score of 50.8% by Mali. (Sokan, 2007).

Similarly, the report of the Second International Science Study (SIS) reveals poor performance of Nigerian students in science subjects, relative to their counterparts in other countries. Nigerian students came last in primary science and second to last in secondary science among the participating countries of the world (Rossier, 1990; STAN, 1992). A similar trend of under achievement in science is further reported by Shelter Right Initiatives (Olubusuyi, 2003) where Nigeria trailed behind other West African countries in science subjects for nine consecutive years.

It appears also that biology students have often failed to develop competencies and skills to a passable level as adjudged by the West African Examination Council (WAEC). The observation is deduced from the poor performance of students in Senior Secondary School Certificate Examinations (SSCE) reported by the West African Examination Council as presented in Table 1.1.

Table 1.1 Performances of Candidates in SSCE May/June Examination (1988 - 2006) in Science Subjects

Year	No. Sat Chemistry	% in Grade 1 – 6	No. SAT Biology	% in Grade 1-6	No. SAT Physics	% in Grade 1-6	No. SAT AGRIC SCIENCE	% in Grade 1-6
1988	34,508	20.70	89.342	9.30	26.297	31.50	62.715	30.80
1989	35,705	10.80	87.710	11.80	23.525	9.50	63,690	20.00
1990	80,095	4.10	190,386	18.70	83,161	20.70	150,587	25.20
1991	116,529	10.40	285,690	25.69	95,742	17.60	220,221	21.90
1992	140,856	19.00	355,582	23.40	22,809	16.40	273,040	29.70
1993	170,537	23.00	481,034	18.70	152,275	24.50	378,607	38.50
1994	161,232	23.70	501,384	11.40	146,000	14.70	395,278	33.50
1995	133,188	36.70	453,353	18.90	120,768	18.90	361,973	41.30
1996	141,990	33.46	506,628	15.95	132,767	12.75	101,676	22.90
1997	172,383	25.58	609,026	15.79	157,700	9.35	389,650	16.20
1998	182,659	21.39	626,894	34.44	169,657	11.33	503,700	23.40
1999	223,307	31.08	755,102	27.81	210,271	30.57	599,101	31.50
2000	195,810	31.88	629,291	19.30	188,312	30.05	488,617	19.29
2001	301,740	36.25	995,345	23.25	287,993	34.41	792,981	36.44
2002	309,112	34.89	1,047,235	31.39	298,059	47.66	832,949	33.31
2003	320388	49.66	1,005,553	42.22	305501	46.90	821034	41.84
2004	142480	40.03	1,005,894	29.68	326091	48.83	375475	25.01
2005	359296	51.33	1,051,557	35.74	345640	41.70	875997	15.65
2006	393206	43.34	1137181	49.23	379365	58.29	950552	35.56

Source: The West African Examination Council (Test Development Division Centre) 2007

This available statistics from West African Examination Council (WAEC) reveals that biology as a subject records the highest enrollment and the lowest percentage pass as against other sciences including Agricultural Science till 2002. In 2002, over one million students sat for the May/ June Biology Examination, but only 31.39% passed at credit level grades 1 – 6. Up to 2006, less than 50% passed at the credit level in Biology. This seems to indicate that students' performance has fallen below expectation despite the enthusiasm demonstrated by both the policy makers and the implementers.

A number of factors have been identified as militating against students' attainment of the objective of science instruction but the commonest factor is the inappropriate and uninspiring teaching strategies adopted by science teachers – (Ali, 1984; Okeke, 1986; Olanrewaju, 1986; Okebukola, 1997; Baron, 2000; and Nwagbo, 2001). A great deal of research effort in science education has centered on the improvement of instructional strategies as a way of proffering solution to the recurring low performance in science subjects especially in Biology. (Akubuilo, 1995; Ajewole, 1994, James and Shaibu 1997).

Recent reforms in mastery learning including Science Technology and Society (STS) initiatives emphasise the teaching and learning of science in the context of human experiences. .However, few researchers have evaluated the effectiveness of teaching programmes in the classroom (Lawson, 1988; Glordan, 1996). Taking the above into considerations, there is a need for a teaching strategy that emphasizes the process of arriving at an answer rather than simply requiring students to regurgitate the "right" answer - whether or not they understand either the answer or its justification. Also, there is a need for a strategy that focuses on process, not product, and provides content for the information that students acquire and is effective and flexible.

With the constructivism movement in science education, a large body of empirical data have been provided that shows that students often come to science classes with conceptions concerning a whole range of scientific domains that do not coincide with accepted scientific thought (Carmichael et. al, 1990; Duschl and Gitomer, 1991; Driver et al, 1994 and Dfundt and Duit, 1994).

The four major Worldwide Reforms in Science Education before the turn of the 21st century embrace four major goals which are:

i. Science for all will lead to better development (Jenkins, 1997)
ii. Teaching for understanding and application of science knowledge and principles will lead to productive work (Scott, 1998)
iii. Inclusion of a broader view of science in the curriculum will incorporate local practices (Cobem, 1998)
iv. Less is better (this will avoid overloading the curriculum) (Solomon, 1999)

These major goals aim at attaining mastery in learning. By the turn of the century, Gallagher (2000) affirmed that only a small percentage of students who studied science in high school came out with any degree of understanding or "love" of science. Eyibe (1990), Jegede (1992), Okebukola (1997) and Salau (1995) all asserted that a large number of students seem to learn very little science at school, learning tends to be by rote and many students find science learning difficult, boring and not interesting. Hence, different authors and researchers have investigated the causes for the low learning outcomes. Evidence from literature indicate that assessment also need to be broadened (Baker & Stites, 1991: Cizek & Rochor, 1994, Ferrara & Mctighe, 1992: Stiggins, 1991a, Busari, 1997; 2001, Udeani, 2002; Baiyelo, 2000). For example Airasan (1994), suggested that assessment should include: The full range of information teachers gather in their classrooms, information that helps them understand their pupils, monitor their instruction, and establish a viable classroom culture

Gallagher (2000) advocated strongly that there should be a shift from the old vision about teaching and learning science to the current reform vision in science teaching. In simple terms, the old vision about teaching and learning has the following attributes:-

- Knowledge is viewed as a commodity that can be transmitted
- Teaching is viewed as transmitting information
- Learning is viewed as memorization, and
- Assessment is viewed as a summative task that distinguishes between those who learned and those who did not.

The 21st century reforms in science teaching have the following characteristics:

- Knowledge is not a commodity that can be transmitted but the result of individual, personal transformation of factual elements and relationships into a coherent form by the learner. In concise terms, this vision holds that knowledge must be constructed by individual learners.
- Teaching is viewed as guiding the students towards valid construction of knowledge, recognizing that unguided construction of knowledge freqΰently does not conform to the scientific canon.
- Learning is a process of making sense of new information and reconciling new and prior knowledge to create a new level of understanding and application.
- Assessment is viewed as formative in guiding both teacher and students toward deeper understanding of, and reasoning about the instructional topic. (Gallagher, 2000).

According to Gallagher (2000), if teachers are to participate in the contemporary reform in science teaching, it is essential that they adopt this new vision about teaching and learning and abandon the former one. This is the foundation of Gallagher's Embedded Assessment Strategies and his Mercedes Model for teaching and learning science for understanding and application.

In 1992, a small group with Professor J. Gallagher at Michigan State University began a developmental project to enable teachers use the embedded assessment (also known as formative, continuous, or classroom-based assessment) as a tool for improving students' learning in Science and Mathematics. The purposes and processes of embedded assessment are to help teachers obtain information about students' ideas and reasoning while they are learning science and mathematics; interpret and make use of some of the information so teachers can understand the difficulties students encounter during the learning process that impede understanding; and determine the next instructional steps that will lead to improvement in understanding and application of the knowledge. These processes are called the "embedded assessment cycle" which led to the development of resources and materials as well as teaching and staff development models. Gallagher (2000) asserted that "without continuous embedded assessment as a central part of a teacher's instructional approach, it is impossible for a teacher to teach for understanding.

Gallagher (2000), after exploring different conceptual models of teaching and learning formulated model that has been useful in helping teachers see their role in teaching for understanding and application of science knowledge more vividly. The model is called the Mercedes Model, for obvious reasons because it points up three aspects of teaching for understanding and application of knowledge – (i) building a knowledge base (acquisition of factual information), (ii) generating understanding (in the straight forward terms of making sense of information and making connections between new information and students' existing ideas), and (iii) finding application. (making connection between concepts and the real world" experience) (Fig 1.1). One feature of this model is that it helps teachers to comprehend that each of these three components of learning for understanding and application requires different teaching strategies.

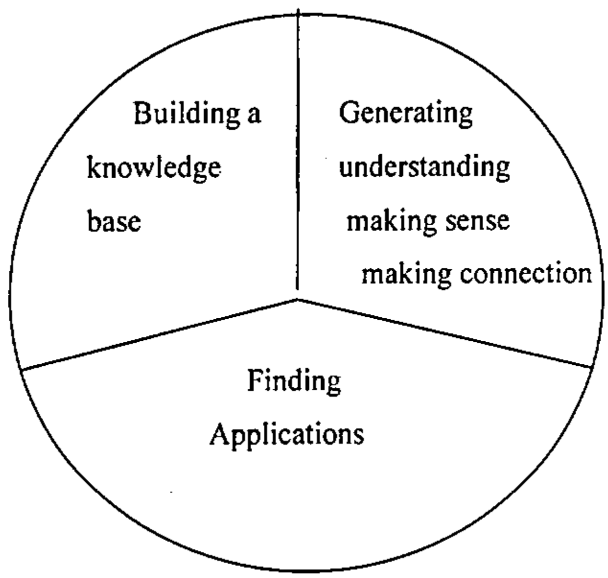


Fig. 1.1 Mercedes Model

In all, Gallagher identified 13 teaching/assessment strategies for the Mercedes Model which are:

Table 1.2 **13 Teaching/Assessment Strategies for Mercedes Model**

Strategy	Description
1. Journal Writing	Any of the strategies described below can be the basis for an entry in students' journals. Journal writing is an effective way of hearing what students are thinking and understanding.
2. Mind Stretcher	A question or a set of questions posed by the teacher that students answer individually, with a relatively brief written response.
3. Student Generated Questions	Students formulate questions that they wish to have answered or are puzzled by. Students can direct the questions towards themselves, peer, teacher, or other predetermined audiences.
4. Peer Analysis	Students analyse, expand on, and/or modify (anonymous) examples of classmates' work. This can be used in conjunction with any of the other strategies.
5. Models, Pictures and Diagrams	Students explain general concepts or specific phenomena using a model, picture, or diagram, as an alternative way of thinking about something. Student can create these themselves or use one

	suggested by the teacher. Students can work from the alternative representation to the idea or vice versa. (A verbal or written explanation included for in the interpretation of the picture, diagram, or model is an important part of this strategy.
6. Concept Mapping	Students generate pictorial representation of the connection between ideas.
7. Preposition Generation	Students write one or two sentences explaining the connection between two concepts.
8. You Become The Teacher	Students are assigned the task of preparing and teaching a lesson on a particular topic or idea to a specific group. Students can work individually or in small groups to prepare a written plan for how to teach the topic. If possible, students should actually teach the lesson to a real student body or audience.
9. Making and Interpreting Graphs	Students make graphs based on their own or other data and then use the graph to answer questions or explain their experiment.
10. Laboratory Demonstration	Students or teacher use equipment or materials in order to experience a phenomenon, become familiar with

	equipment, or develop measuring skills. They then try to explain the phenomenon or write about how they would use the skills or equipment.
11. Laboratory Experiments/Record Observations	Students design, perform, and/or analyze controlled experiments. Students can do any part or parts of this process.
12. Inquiry Projects	Students explore an object or a phenomenon with the intent of understanding it. The project can take many forms. Students can choose a topic or choose the means to a given end. Throughout the process the students have opportunities to direct the inquiry within certain limits.
13. Justification of Selected Answers of Multiple Choice Test	Students write or verbally explain their choice of a particular answer and their rejection of other answers to a multiple choice question.

For the Mercedes Model to be an effective model of instruction, Gallagher (2000) asserted that it is essential that an overlay of continuous formative, embedded assessment be added (see Fig. 2). This is in line with the framework of constructivist teaching. (Brooks and Brooks, 1998).

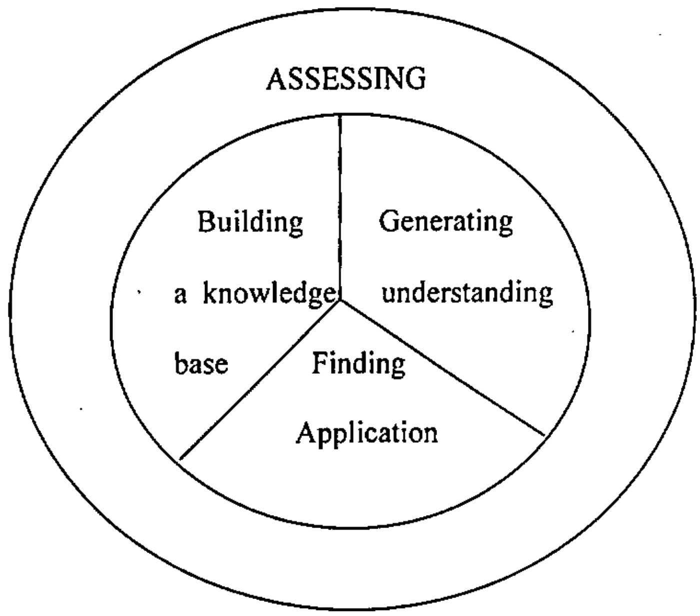


Fig. 1. 2: Mercedes Model and Embedded Assessment

It is undeniable that many students find it hard to grasp some ideas in science. No matter the road through which students get into the academic jungle of acquiring science concepts, in general and biology concepts in particular, two major facts are pertinent; learning biology is a complicated and hard routine; and even more problematic is understanding and applying biology concepts to real life. Nonetheless, if we must participate in the current world wide Science reforms, it is expedient we investigate further on teaching and learning strategies which has been identified as one of the major factors responsible for students poor performance in biology. (Bajah, 1998; Lasis, 1998; Obemeatu, 1995; Osisioma, 1994; Eniayeju and Eniayebu, 1992; Oyekan, 1993; Okebukola, 1990).

Since one of the cardinal functions of the 6-3-3-4 system of education in Nigeria is "preparing the child for life". Then for our students to prosper in this new century, all of them must become scientifically literate and embrace the notion of lifelong learning in science. Here lies the essence of this study. A situation whereby performance of students in biology is significantly falling below expectation and assessment neglected until the dying moment cannot be allowed to remain unchecked.

Larger biology classes occasioned by the fact that more students offer biology as the only science subject and may not encounter science again after secondary school level calls for an urgent intervention. There is need to find ways and means of motivating the students to benefit maximally from the teaching of biology. A systematic, and innovative instructional/ assessment strategy that would improve the scenario is therefore necessary.

1.2.0 Statement of the Problem

The poor performance of students in the school certificate examination has led to the criticism of biology teaching and learning (Ajewole, 1984). The ineffectiveness of the strategies traditionally employed by science teachers has been attested by several researchers (Weiss, 1977; Novak and Godwin, 1984; Stake and Easley, 1984; Welch, 1985; Martin and Ramsden, 1986; Biggs, 1988; Okebukola et.al, 1990; Iroegbu, 1998; Baron, 2000). Consequently, attention is drawn to the need for alternative strategies for teaching science more meaningfully to learners.

Research had shown that in most public schools, the classroom population is conspicuously large and difficult to manage by teachers. More often than not, when a teacher manages to teach three arms of a particular class level, other students from the rest of the arms only enjoy the activity of a class captain who collects lesson notes from the subject teacher and copies such on the chalk board for the students (Okebukola 1997, Esiobu 2001). The researcher's observation on a survey study through video slides also revealed that teachers are the major role players who usually dominate all activities during teaching/learning situations. Students only keep quiet and pay rapt attention during periods of lessons. The teaching style is basically lecture method in which the students are bombarded with a lot of concepts that they can hardly comprehend.

Similarly, assessments of classroom activities are hardly done and if at all, it is summative assessment which is basically on recall of factual knowledge and not application of knowledge or problem solving skills. This is contrary to the policy on education which advocates for continuous assessment. It may be that teachers avoid assessment because of large class sizes. On the other hand, students hardly can apply or relate the classroom lessons to events in their immediate environment. For example student in Senior Secondary II (SS II) could not explain why a frozen can drink drips water after it has been brought out of a freezer.

The above assertions and observations support the findings of Ajewole, 1994; Udeani, 2000; Folaranmi, 2002; Ogunleye, 1999; Okebukola, 1997; and Olaleye, 2002 that indicate large class sizes, lack of textual materials, inadequate laboratory apparatus/equipment and lack of provision in many homes for the educational needs of students in science as impediments of effective science education. Nwosu (2000) also observed that Biology is still being taught through the "Chalk and Talk" method and few practical classes are conducted close to the examination period at the senor secondary school level. Okebukola (1997) paints a depressing description of science teaching in Nigerian Schools when he asserts:

> The science class begins with a brief chat as an introduction. This is followed by the reading of the notes by the teacher to the students. At the end of the lesson, the left over notes on the topic is given to the class captain. In the class free time, the class captain copies the notes on the board or models the teacher by reading the notes for other students to copy.

2. examine the influence of Senior Secondary School subject specialization on students' knowledge, understanding and application of biology concepts.

3. determine the extent to which gender affects students' knowledge, understanding and application of biology concepts.

1.4.0 Research Questions

The following research questions were raised to guide the conduct of the study:

1. Will the Mercedes Model with the Embedded Assessment Strategy enhance students' knowledge, understanding and application of selected biology concepts?

2. Will students' subject specialization influence their knowledge, understanding and application of selected biology concepts in the experimental and control group?

3. Does gender influence students' knowledge, understanding and application of selected biology concepts?

4. Will there be a significant interaction effect of treatment and subject specialization on students' knowledge, understanding and application of selected biology concepts?

5. Is there a significant interaction effect of treatment and gender on students' knowledge, understanding and application of biology concepts?

6. Is the interaction effect of subject specialization and gender significant on students' knowledge, understanding and application of biology concepts?

7. Will there be a significant interaction effect of treatment, subject specialization and gender on students' knowledge, understanding and application of biology concepts?

1.5.0 Research Hypotheses

The following hypotheses were postulated and tested in the study at 0.05 level of significance.

1. There is no significant difference in students' knowledge, understanding and application of selected Biology concepts after exposure to the Mercedes Model with Embedded Assessment Strategy and in the control group.

2. There is no significant difference between science and non science students' knowledge, understanding and application in the experimental and control groups.

3. There is no significant gender difference in students' knowledge, understanding and application of selected biology concepts in the experimental and control groups.

4. There is no significant difference in the science and non-science students' knowledge, understanding and application of selected biology concepts in each of the experimental and control groups.

5. There is no significant gender difference in students' knowledge, understanding and application of selected biology concepts in each of the experimental and control groups.

6. There is no significant difference between the science and non science students' knowledge, understanding and application of selected biology concepts among those who are males and females after exposure to experimental and control groups.

7. There is no significant difference in the students' knowledge, understanding and application of selected biology concepts among those who are males and females in science and non-science classes exposed to the experimental and control groups.

1.6.0 Scope of Study

The study developed and utilized the Mercedes model with embedded assessment as an instructional package to teach Senior Secondary Class II students towards improving their knowledge, understanding and application of concepts in selected biology topics. Six schools were randomly selected from two Educational Districts in Lagos State. The selected concepts of biology considered are diffusion and osmosis which have been identified as very important towards the understanding of many important life processes, related to other science subjects such as physics and chemistry and have been linked with the poor performance of students in the subject by WAEC Chief Examiners' Reports.

1.7.0 Limitations of Study

The timing of data collection from school was made to coincide with the school timetable and Biology scheme of work for SS II. However, shortly after resumption of first term, teachers were engaged in promotion exercise. Many teachers had to study to prepare for the exercise. Consequently, it was difficult to carry out the research until the teachers were through with the promotion exercise. Also, some of the biology teachers selected for the research were re-deployed to another school in other Educational Districts. All these problems were surmounted research.

1.8.0 Significance of the Study

The study would help in the effective delivery of science instruction to students at secondary school level. This would boost the performance of our students and in the long run would be of immense benefit to our nation Nigeria as it aims to rank among world leading scientifically, technologically, industrialized and developed nations by the year 2020. Teaching for understanding and application of science for a much wider spectrum of the school population will enhance the much needed scientifically literate populace, which in turn will bring about scientifically literate work force.

The results from the study would bring to the fore, the need to review, overhaul and develop new curricula in science for the different grade levels of schooling. It will also act as a spring board for our policy makers to make worthwhile education decision in the light of the new wave of education reforms on the global scene.

The facts and figures emanating from this study would equally be an eye opener and a great asset to teachers and teacher educators as they begin to view teaching and assessment in the way of the new vision of the contemporary reform in science teaching (constructivist pedagogy) which will inform a paradigm shift in their classroom practices in science education.

Since the study presents science teaching as activity based using the constructivist pedagogy, students "love" for science and cognitive achievement would be enhanced, hence, an increase of science students' enrolment and retention in the science class

In line with Reforms Worldwide, this study would be economically driven. Most governmental and industrial leaders see the need for a technologically literate workforce as essential to the economic health of the nation and business. Thus, a research of this nature which promotes teaching science for understanding and application is perceived as having a direct bearing on wealth, power and influence.

The study would also have a positive feedback effect on the citizenry. Man in general and students in particular are able to interpret what happens in his environment, make sense of it and use it to improve his living thereby eradicating poverty and hunger. Also, man and students become environmentally friendly when they are scientifically literate. Consequently, man is able to heed the warning of the passionate environmental campaigner – Prince Charles of Wales (2009) who expressed emphatically that the world has "less than 100 months to act if it is to save the planet from irreversible damage from escalating global warming.

Finally, a study of this nature is a must for every developing nation because of its inherent advantages which tend to project nations for science and technological advancement.

1.9.0 Theoretical Framework

This research work hinges on some cognitive teaching and learning theories namely:

(a) Twentieth century cognitive theorists on Discovery Learning (Williams James, John Dewey and Jerome Brunner).

(b) Bloom's cognitive taxonomy

(c) Ausubel's theory of meaningful learning

(d) Piaget's and Vygotsky's theories of cognitive development

(e) The constructivist theory of learning

a. **Twentieth Century Cognitive Theorists on Discovery Learning:**

William James (1842-1910) gave a series of lectures called: Talks to Teachers (James, 1899/1993) in which he discussed and argued for the importance of observing teaching and learning in classrooms for improving education. One of his recommendations was to start lessons at a point just beyond the child's level of knowledge and understanding in order to stretch the child's mind.

John Dewey (1859 - 1952) viewed the child as an active learner. He believed that children learn best by doing. He also opined that education should focus on the whole child and emphasize the child's adaptation to the environment. He pointed out as well that children should not be just narrowly educated in academic topics but should learn how to think and adapt to a world outside school. He especially thought that children should learn to be reflective problem solvers and deserve competent education. John Dewey (1933) and Jerome Bruner (1966) further promoted the concept of discovery learning (in contrast to the direct instruction approach) by encouraging teachers to give students more opportunities to learn on their own. He viewed discovery learning as a way of encouraging students to think for themselves and discover how knowledge is constructed. It also feeds their natural curiosity and inquiry. Researchers have found that students in activity_based, discovery_learning science classes score higher on science achievement tests than students in traditional direct instruction science class (Bredderman, 1982; Glasson, 1989). However, most discovery learning approach used in schools today do not involve "pure" discovery learning hence, the development of guided discovery learning in which students, are still encouraged to construct their understanding, but with the assistance of teacher_guided questions and direction.

b. **Bloom's Cognitive Taxonomy**

Benjamin Bloom and his colleagues (1956) developed taxonomy of education objectives in three domains: cognitive, affective and psychomotor. Bloom's cognitive taxonomy has six objectives, which are:

1. Knowledge: Students have the ability to remember information
2. Comprehension: Students understand the information and can explain it in their own words..
3. Application: Students use knowledge to solve real life problem,
4. Analysis: Students break down complex information into smaller parts and relate information to other information.
5. Synthesis: Students combine elements and create new information
6. Evaluation: Students make good judgments and decision.

Bloom's cognitive objectives can be used when planning assessment. The affective taxonomy consists of five objectives related to emotional responses to tasks. Each of the five objectives requires the students to show some degree of commitment or emotional intensity.

1. **Receiving:** students become aware of or attend to something in the environment.
2. **Responding:** Students become motivated to learn and display a new behaviour as a result of an experience.
3. **Valuing:** Students become involved in or committed to some experience.
4. **Organising:** Students integrate a new value into an already existing set of values and give it proper priority.
5. **Value characterizing:** Students act in accordance with the value and are firmly committed to it.

The psychomotor domain - Bloom's psychomotor objectives include these:

1. **Reflex Movement:** student responds involuntarily without conscious thought to a Stimulus.

2. **Basic Fundamentals:** Students make basic voluntary movements that are directed toward a particular purpose.

3. **Perceptual Abilities:** Students use their senses such as seeing, hearing or touching to guide their skill efforts.

4. **Physical Abilities:** Students develop general skills of endurance, strength, flexibility and agility.

5. **Skilled Movements:** Students perform complex physical skills with some degree of proficiency.

6. **Non-discursive:** Students communicate feelings and emotions through bodily actions.

Bloom's taxonomies for the cognitive, affective and psychomotor domains can be used by teachers to plan instruction.

c. Ausubel's Theory of Meaningful Learning

This theory believes in the role of prior knowledge in cognitive structure and the effect which sequential organization of subject matter has on the stability and clarity of anchoring ideas for subsequent learning. In other words, the incorporation of new concepts and information into an existing and established cognitive framework is largely influenced by the students' past experience and the integrative nature of subject_-matter discipline. It was David Ausubel who first introduced a pre_instructional strategy which he called "Advance Organizer". Advance organizer is based on the cognitive view. The cognitive field theorists, otherwise referred to as the gestaltist, consider mental processes as essential factors in learning. They stress the importance of the internal operation (O) of the learner, which result in learning as a necessary means of controlling the stimulus(S) and of determining the Response (R). Some of the proponents of this theory include Koffika, 1935; Piaget, 1947; Ausubel, 1963; and Bruner, 1983; Okebukola, 1999 and Snead, 2002).

d. **Piaget's and Vygotsky's Theories of Cognitive Development**

Poet Neah Perry once asked "who knows the thoughts of a child?" More than anyone, the famous Swiss psychologist Jean Piaget (1896 _1980) knew. Piaget emphasized that children learn best when they are active and seek solutions for themselves _ rather than blindly imitating the teacher or doing things by rote. Effective teachers are to design situations that allow students to learn by doing. This situation according to him will promote students' thinking and discovery. According to Piaget, students do not come to class with empty heads. They have many ideas about the physical and natural world. They have concepts of space, time, quantity and causality. These ideas differ from the idea of adults. Some of the general principles in Piaget's theory that can be applied to teaching are the use of ongoing assessment and the turning of the classroom into a setting of exploration and discovery. Vygotsky believes that children actively construct their own knowledge. Vygotsky believes that teaching should begin toward the zone's upper limit where the student is able to reach the goal only through close collaboration with the instructor (student's zones of proximal development in teaching).

e. **Constructivist Theory of Learning**

The Constructivist theory of learning assumes that learning is seen as an adaptive process, one in which learners' conceptual schemes are progressively reconstructed so that they are in keeping with a continually wider range of experiences and ideas. It is also seen as an active process of sense making over which the learner _ has some control.

According to Yager (1990), every individual construct and reconstructs knowledge in the process of assimilating knowledge and relating it to real life. It is favoured for the following:

1. Focusing on epistemological issues in learning and curriculum (Philip, 1995).
2. Enhancing our knowledge of difficulties in learning science (Osborne, 1998).
3. Fostering the development of innovative methods of science teaching (Osborne, 1996).

From the foregoing, William James and Jerome Brunner recommended that a child's mind should be stretched. This principle is similar to "Mind Stretcher Strategy" which is one of the five teaching and assessment strategies that is being used in this present study.

John Dewey however, emphasized the need for the child to be well adapted to his/her environment. This assumption is one of the bedrock of the Mercedes Model which aims at teaching for understanding and application of the concepts of osmosis and diffusion.

In the same vein, the Bloom's Taxonomy consisting of objectives often used for planning assessment are similar to the thirteen (13) teaching and assessment strategies in the Mercedes Model. However, these thirteen strategies are overlay on the Mercedes Model and they formed the embedded assessment strategies. Five of these thirteen EAS are used in this study. These include mind stretcher, models, pictures and diagrams, preposition generation, laboratory demonstration, laboratory experiment/record, observation.

In its own case, Ausubel's theory of meaningful learning postulates sequential organization of subject matter. Likewise, the Mercedes Model identified three components necessary for teaching for understanding and application. These are: Building Knowledge, Generating Understanding, and Finding Application. This sequence is such that ensures the proper mastery of the subject matter rather than teaching for knowledge alone. One of the recent reforms which built on the work of Piaget and Vygotsky is the theory of constructivism. This explains that teachers facilitate learning by providing appropriate activities. So students can construct their own understanding of concepts. The Mercedes Model used in this study derives inspiration from the constructivism theory. One of the visions of the Mercedes Model is that knowledge must be constructed by individual learner and teaching is as guiding the student towards valid knowledge.

On the whole, the Mercedes Model as it is used in the present study is an aggregate of most of the twentieth theories, Bloom's taxonomy, Ausubel, Piaget and Vygotsky theories, and constructivism Nonetheless, the Mercedes Model has added more features geared towards optimizing understanding and application of science concepts. This is in the area of embedding the assessment strategies with the Mercedes Model.

1.9.1 Operational Definition of Terms

Mercedes Model: This is a model for teaching and learning as developed by Gallagher (2000). The utility of this model is that it points up three aspects of teaching for understanding and application of science concepts - building a knowledge base, generating understanding and finding application.

Building Knowledge Base: This contains familiar, standard teaching practices that serve to transmit information to students.

Generating Understanding: In this component, students are involved in many activities where they become agents in developing their own understanding.

Finding Application: This is the central part of learning which helps the student identify practical applications of concepts, use practical experiences and application to make connection between concepts and "real world" experiences.

Conventional Method: This refers to the modified lecture method commonly used by teachers in schools. Here the students are seen as mere receivers of knowledge during the teaching/learning process. All the activities of the teaching are directed by the teacher. It allows minimal teacher-students, student-teacher and student-student interaction. It is teacher-centered and subject-oriented.

Intact Class: This refers to the group of students as they are in their classes without disrupting the class arrangement.

Cognitive Achievement: This refers to the students' proficiency in the learning of the selected biology concepts expressed in their scores in knowledge, understanding and application components of the Mercedes Model.

Learning Outcomes: This is the students' cognitive achievement in knowledge, understanding and application in biology.

CHAPTER TWO

LITERATURE REVIEW

2.1.0 INTRODUCTION

This chapter presents the review of related literature on the study which centered basically on effective teaching for mastery learning. The review of related and relevant literature on the study therefore, was put together under the following sub-headings:

- Goal - Based Studies (1916 - 1963) – The Humble Beginning of Mastery Learning
- Mastery Learning
- Constructivism,
- The Meaning of STS
- Some Teaching Models
- Research on Gender and Science Education
- What is Assessment?
- Subject Specialization
- Summary of the Literature

2.2.0 Goal - Based Studies (1916 - 1963) - The Humble Beginning of Mastery Learning

John Dewey (1859 – 1952): was one of the pioneers in the field of educational psychology to challenge the old "static cold storage ideal of knowledge" and in bringing education more into accord with the actualities of present day life. Before Dewey, it was believed that children should sit quietly in their seats and passively learn in rote manner. In contrast, he believed that children learn best by doing and the education should focus on the whole child and emphasize the child's adaptation to the environment. He believed that children should not be just narrowly educated in academic topics but should learn how to think and adapt to a world outside school. Many of Dewey's ideas are still embodied in current views of how children should be educated.

2.3.0 Mastery Learning: A Definition

Mastery learning is basically in two dimensions. First, mastery learning is an old, optimistic philosophy about teaching and learning. This philosophy asserts that any teacher can help almost all students to learn excellently, quickly, and self-confidently; the teacher can help "dumb", "slow" and "unmotivated" students to learn like "smart", "fast", and "motivated" students. This kind of learning, the philosopher contends improves many students as well as teachers chances for long-term social and personal prosperity. Students in particular, acquire those basic personal competencies which ensure that they can and want to undertake life- long learning competencies. Likewise, teachers acquire some basic professional competencies.
Second, mastery learning is a set of old and new individualized instructional ideas and practices that consistently help most students to learn excellently, quickly, and self_confidently. These ideas and practices produce instruction that is systematic, provides help to students when and where they have learning difficulties, provides sufficient time for students to achieve mastery and provides a clear criterion of what constitutes mastery (Bloom, 1974 p.6)

In other words, mastery learning is an instructional philosophy based on the belief that all students can learn if given the appropriate amount of time and the appropriate instructional opportunities. It is believed that students can achieve mastery when the curricular standards are clearly articulated and defined, when assessments accurately measure the students' progress toward performance of the objective(s) when instructional lessons are tightly aligned to the curriculum.

Mastery learning is based on several premises that include:

- All individuals can learn
- People learn in different ways at different rates
- Under favourable learning conditions, the effects of individual differences approach a vanishing point
- Uncorrected learning errors are responsible for most learning difficulties.

What defines mastery learning approaches is the organization of time and resources to ensure that students are able to master instructional objectives. Small group instruction, cooperative learning, use of differentiation activities, discovery learning, discussion group, are many different instructional strategies that teachers use in the classroom that support mastery learning. Regardless of the instructional strategy used, Bloom, Guskey and others have outlined what teachers do in mastery learning classroom.

- Teachers determine what the students will know and what they will be able to do after the lesson.
- Content is divided into small learning units and tools or processes are developed to check students' progress and learning.
- After the material from the unit is presented, an assessment is administered to determine each student's progress and to identify areas in which more instruction may be needed (Formative Assessment).
- Information is given to the student about their learning progress (Feedback). This "feedback" reinforce precisely what was most important for the students to learn in each unit of instruction, recognizes what students learned well, identifies the specific concepts on which students need to spend more time and is appropriate for students' level of learning.

- A student scoring at a high level of performance based on specific criteria on an assessment will move directly into activities that provide opportunities for them to broaden, expand, or deepen their learning (Enrichment) or may be moved on to the next unit of study or group of objectives to be mastered (Acceleration);
- Students who have not mastered the material are engaged in activities that offer guidance and direction on how they can correct their learning error and remedy their learning problems (correctives). Students are provided with alternative learning methods and then given another formative assessment to check for mastery.
- At the end of the unit(s), the teacher evaluates the final competence of students by giving a summative Assessment covering the objective of the unit. After the assessment is given, teachers evaluate the results and plan next steps.

"Mastery learning is usually implemented through a careful process of organization and planning, followed by specific procedures for classroom application and student assessment and evaluation. Mastery learning does not challenge teachers' professionalism or academic freedom, but instead offers a useful instructional tool that can be flexibly applied in a variety of teaching situations. Although it is not an educational cure_all, mastery learning significantly increases the positive influence teachers can have on student learning" (Guskey, 1997).

2.3.1 A Historical Perspective of Mastery Learning

Mastery Learning is an instructional strategy developed by Carroll (1963) and promoted by Bloom (1968). Its evolution as a model of school teaching and learning falls into two distinct periods. The first period is called the "Bloom Period" spanned the years from 1968 to 1971 was dominated by the writings of Bloom at the University of Chicago.

The second period called the "Post Bloom Period" spanned the time from 1971 – 1979 and was dominated by the writings of Bloom's students and colleagues.

2.3.2 The Bloom Period

Bloom's theoretical contribution to the evolution of mastery learning was to transform the conceptual model of school learning developed by Carroll (1963) into a working model for mastery learning. Central to Carroll's model were three propositions:

(a) Aptitude could be viewed as an index of learning rate, rather than learning level.

(b) The degree of learning for any student in a school setting is a simple function of the time he or she actually spends in learning relative to the time he or she needs to spend.

(c) In a school learning situation, the time a student actually spends learning a subject as well as the time he or she needs to spend will be determined by certain instructional and personal characteristics.

Bloom further combined these three propositions as follows:

If aptitude is predictive of the rate at which, rather than the level to which, a student could learn, it should be possible to fix the degree of learning expected of students at some level and to systematically manipulate the relevant instructional variables in Carroll's model such that all or almost all students attained mastery. Bloom argued that if students were normally distributed with respect to their aptitude for a subject and were provided uniform instruction in terms of both quality and time, then their _ achievement at the subject's completion would be normally distributed. Furthermore, the relationship between aptitude and achievement would be high.

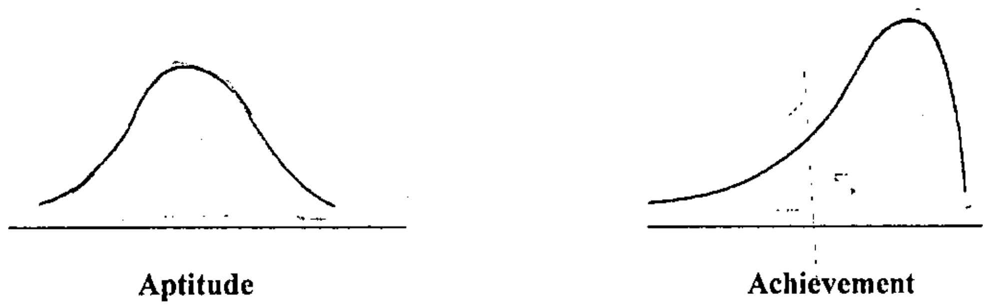


Figure 2.3: Uniform Instruction per Learner

However, if students were normally distributed on aptitude but each received optimal quality of instruction and adequate learning time, then a vast majority of students could be expected to attain mastery. In addition, there would be little or no relationship between aptitude and achievement.

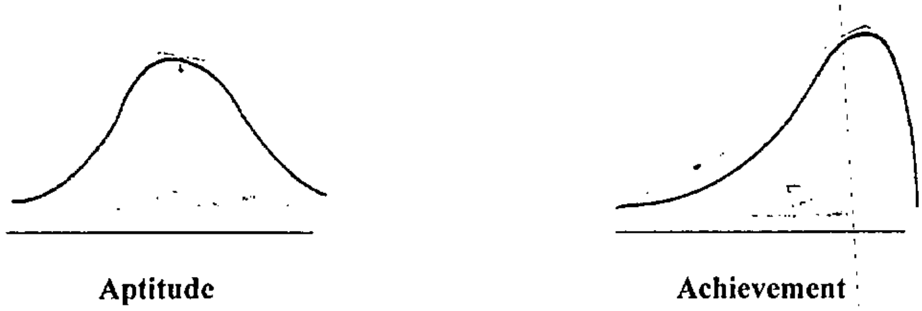


Figure 2.2: Optimal Instruction per Learner

Bloom's practical contribution to the evolution of the mastery learning approach to instruction was to outline a classroom teaching strategy that would systematically vary, as necessary, how and how long each student was taught. For this reason, Bloom returned to the approach of Washburne (1922) called the "Winnetka Plan" and the approach of Morrison (1926) at the University of Chicago's Laboratory school. Out of the similarities of these two approaches, Bloom culled the basic element of his own approach. Some of these elements are summarized by McNeil (1969) as follows:

(a) The learner must understand the nature of the task to be learned and the procedure to be followed in learning it.

(b) The specific instructional objectives relating to the learning task must be formulated.

(c) It is useful, to break a course or subject into small units of learning and to test at the end of each unit.

(d) The teacher should provide feedback as to the 'Learner's particular errors and difficulties after each test.

(e) The teacher must find ways of altering the time some individuals have available to learn.

(f) It may be profitable to provide alternative learning opportunities.

(g) Student effort is increased when small groups of two or three students meet regularly for as long as an hour to review their test results and to help one another overcome the difficulties identified by means of the test.

2.3.3 Post - Bloom Period

Bloom turned his attention to developing the theory (Bloom 1976), but a number of his students and their colleagues devoted their attention to developing the practice.

Initially, the efforts of some of these individuals were concentrated on applying the theory and related practices to the improvement of classroom and then school_ wide practices. However, it became apparent that interest in the evolving mastery learning approach had spread far beyond the classroom and school level. Consequently, the efforts of many individual shifted to the improvement of system-wide practices.

Since the mid-1970s, mastery learning has been applied to an ever_increasing variety of subject areas and extended beyond the secondary school level. Such subjects as geography, biology, psychology, sociology, music, public speaking, allied health, nursing, pharmacy, and veterinary pathology.

2.3.4 Studies on Mastery Learning

Studies on the mastery learning model of teaching and learning is abundant. However, the three major generalization that can be derived from the comprehensive reviews of the studies by Block and Burns (1976), Bloom (1976), Dolan (1977_78), Burns (1979), and Gaskey and Gates (1985), are presented below.

2.3.5 Effectiveness of Mastery Learning

The effectiveness of mastery learning programmes has been demonstrated repeated by about 90 per cent of the time. Beginning with the early studies which were small-scale, used laboratory like learning tasks, and occurred in rather contrived classroom settings (for example, programmed instruction) and continuing to the present studies which are large scale (often involving entire school districts in the United States, or entire countries such as the Republic of Korea and Indonesia), use school_ related learning tasks, and take place in naturally occurring classroom settings. The generalization that mastery learning is effective is evident to anyone who performs even a cursory examination of the research literature.

Reviews have begun to quantify this effectiveness. Burns (1979), estimated the average "effective size" of mastery learning programmes compared to non-mastery programmes. Based on this estimate, the study suggests that the average student enrolled in mastery learning classes would achieve better than 80 to 85 percent of the students in non-mastery classes. Studies on the effectiveness of mastery learning programmes is not limited to studies of immediate achievement. Although not as numerous as those focusing on immediate achievement, several studies have examined the effectiveness of mastery learning programmes in terms of students' retention and rate of learning, as well as students' attitudes and self perceptions. Results from the vast majority of these studies, students enrolled in mastery learning classes, out_ performed their non-mastery counterparts. This implies that students learning under mastery-based conditions.

(a) retained a greater portion of what they learned;

(b) learned to learn more efficiently;

(c) were more positive in the their attitudes towards the subject being learned; and

(d) developed greater self-confidence in their ability to learn.

2.3.6 The Key to Effectiveness Lies within the Feed back/Corrective Mechanism

The first aspect of this generalization is the level at which mastery performance standard is set: the second is the provision and utilization of corrective instruction. Block (1972) investigated the issue of the setting of mastery performance standards. Block examined the teaching of matrix arithmetic to eighth graders (13-year-olds). Based on his findings, Block concluded that a mastery performance standard set at 95 percent correct produced maximal cognitive learning. However, yet unfortunately, this 95 percent standard had somewhat negative effects on students' attitudes and interests. Setting the standard at 85 percent correct, however, produced maximal interests and attitudes and somewhat reduced, but acceptable, levels of cognitive achievement.

Chan (1981), in his study used a mastery learning approach to teach reading comprehension to third_graders, replicated partially Block's finding concerning cognitive learning. Again, the 95 percent correct mastery performance yielded maximal learning. Students required to attain a lesser standard (i.e., 75 percent correct) achieve no better than did students learning under the non mastery approach. Unfortunately, Chan did not include a standard of 85 percent correct in her study.

Results from these studies on standard setting reveal that the standard must be set sufficiently high so as to ensure that the desired learning has occurred. Standard somewhere between 85 and 95 percent are most appropriate. The second key to the effectiveness of mastery learning is the provision and utilization of corrective instruction. The importance of corrective instruction was first examined by Collins (1970) and established by Block (1970).

Another study by Nordin (1980), provides greater details of the role that corrective instruction plays in the overall effectiveness of mastery learning. Nordin focused on three of the major components of Bloom's (1976) conceptualization of quality of instruction: cues participation, and feedback/correctives. Nordin formed five groups of Malaysian sixth_grade students and provided enhanced cues to one group, enhanced participation to a second, enhanced cues and participation to a third, feedback and corrective to a fourth, and conventional group instruction to a fifth. The result shows that in both cognitive achievement and learning rate, the students in the feedback/corrective group outperformed the students in the other four groups. Also, in terms of student interest, students in the feedback/corrective group were more positive than the students in three of the other four groups. The exception was the enhanced cues group in the feedback/corrective group. The importance of the corrective instruction component of mastery learning can be attributed largely to the increase in time available for learning. There is also, some evidence to suggest that, following corrective instruction, students spend an increasing proportion of the available time, involved in learning or on_ task (Anderson, 1976).

2.3.7 Mastery Learning is Differentially Effective for Different Types of Students

This generalization is derived from studies on two student characteristics: which are ability and age.

(a) Ability: One of the comment questions often posed to proponents of mastery learning is whether students at all ability levels benefit equally well from mastery learning or whether the increased learning of the lower ability students is purchased at the cost of decreased learning of high_ability students. The results from several studies illuminate not this question.

Kim (1969) stratified his sample according to the students' general ability. Two strata of ability, above average and below average, were formed. Students were assigned to either a mastery learning or non mastery class. After the completion of the study, Kim investigated the results of the summative assessment separately by ability stratum. For the high_ability students, 95 percent of the mastery learning students and 64 percent of the non mastery students achieve mastery using 80 percent correct as the summative mastery performance standard. Kim found for the low ability students that 50 percent of those in the mastery learning class as compared with only 8 percent in the non mastery class achieved mastery.

Detheux et al (1974) in another study used socio economic status as a proxy for entering ability level. Three levels of socioeconomic status were formed: Under privileged (60 percent), average (30 percent) and privileged (10 percent). Results from the Detheux et al study suggested that while mastery learning program was especially beneficial for the underprivileged students, all three groups benefited from the program. The Detheux et al study is more important since a more elite group of high ability student (10 percent) was included than in the Kim study (50 percent).

Several studies have been conducted to test the practical application of mastery learning to the classroom situation. One of these studies was carried out by Collin (1980) who investigated the effectiveness of the different variables in Bloom's mastery learning strategy for teaching modern mathematics at Junior high school level involving one hundred and fifty (150) students. Following the completion of the study, Collin observed that there were major differences in the effects of the various treatment in helping students to learn to the mastery criterion of an A or B grade. In the same vein, Kulik et al (1990) reported that mastery - learning students did better on tests developed to fit local curricular. They also found no evidence to suggest that mastery learning had any negative effect on any type of student learning.

Summary of the results of studies which have examined students of different ability levels indicate that the lower ability students, do, in fact, benefit more from mastery learning than the high _ability student. At the same time, however, the high_ ability students do not suffer. Either they also benefit somewhat from the mastery learning program or at the very least, do not do any worse than their high_ability counterparts in non mastery programs (Anderson and Reynolds, 1979).

Chan (1981) in his work devised three sets of reading comprehension items. The first set was targeted for Grade 3, the second set for grade 4 and the third set for grade 5. These sets of items were "Linked together using techniques underlying the Rasch Psychometric model. Since the students were enrolled in grade 3, the summative test was virtually "ceilingless". Chan found that the high_ability students in the mastery learning groups achieved at virtually the same level at their non mastery counterparts.

(b) Age: School - based evaluations of mastery learning programs have begun to look into the impact of these programs at different grade levels (Abrams, 1981; Cohen, 1981). Most frequently these programs have been implemented over a period of several years, typically in grades 1 through 8.

A time-series design has been used to evaluate program effectiveness. The findings from the study suggest that mastery learning programs have their greatest impact on students in grades 5 through 8. Relatively little impact has been seen at grades I through 4.

Summary on results are somewhat surprising given the assertion of both some proponents and critics of mastery learning that mastery learning is especially effective when (a) it is introduced very early in the schooling process and (b) it is employed in the teaching of simple "closed" subjects rather than more complex, "open" subjects. Quite clearly subject matters become increasingly "open" and complex as student, progress through the grades (Block and Burns, 1976). Evidence from studies suggest that the mastery learning model of school teaching and learning represents one of those major breakthroughs to the improvement of student learning and school teaching for which both the educational practitioner community and the educational research, development and dissemination community have been searching.

This growing body of research strongly suggests that mastery learning strategies usually have met, wholly or in part, general research criteria usually unmet by most other innovative approaches to the improvement of the school teaching and learning. Mastery learning strategies can be taught to teachers, are being used, and are effective for large numbers of students.

2.3.8 Studies on Mastery Learning in Nigeria

Ezewu (1981) carried out a study to examine the effects of mastery learning on selected learning outcomes in French using 420 class four secondary school students who were randomly assigned to experimental and control groups. He discovered that there was significant differences between the means of the experimental and control groups in favour of the experimental groups. These were evident in their achievements and attitude towards French. Students in the experimental group attained a mastery performance of 75 percent.

In the same vein, Ajueshi (1990) investigated the unit of a mastery learning problem solving model for facilitating students' problem solving skills in Chemistry. One hundred ninety three (193) students from four co_educational secondary schools were randomly assigned to treatment conditions. Following the completion of the study, the result shows that the mastery learning strategy can be used effectively to enhance both problem_solving strategic knowledge and problem solving confidence thereby increasing success in Chemistry.

Similarly, Adepoju (1999) in his study examined the relative effects of two mastery learning instructional methods on students' learning outcomes in English grammatical structure. The sample consisting of three hundred and three senior secondary II students were randomly selected and assigned treatment groups. The result of the study shows that the two experimental conditions, mastery learning strategy (MLS) and Enhanced mastery learning strategy (EMLS) were more facilitative than the conventional method in improving English language achievement.

Bowen, (2002) in another study on the effect of learning for mastery on student attitude and performance in general chemistry observed changes in students' attitude and achievement in general chemistry during the implementation of learning for mastery programme.

However, mastery learning gets mixed reviews. Some researchers indicate that mastery learning is effective in increasing the time that student spend on learning tasks (Kulik et - al, 1990), but others find less support for Mastery learning (Bangert, Kulik and Kulik, 1983). Outcomes of mastery learning depend on the teacher's skill in planning and executing the strategy. One context in which mastery learning might be especially beneficial is remedial reading (Schunk, 1996). A well organized mastery learning program for remedial reading allows students to process at their own rates based on skills, their motivation, and the time they have to learn.

2.3.9 Constructivism, Conceptual, Change and the Science Curriculum

Piaget was one of the early proponents of constructivism, seeing children as constructing their own knowledge through their own activity, or in Piagetian terms through the processes of assimilation and accommodation. Assimilation is the activity that permits the gradual incorporation of new ideas and information into a person's mental schemes, that is to say when people tackle new situations they try to incorporate the novelty of the outside world into what they already know and understand. New ideas and information are not always readily assimilated, so that a person's understanding is constrained. Individuals do not submit passively to such constraints but adjust their thinking, their mental schemes, so that they can deal with these novel ideas and information. Thus, accommodation is the activity of modifying assimilatory schemes.

From the 1970s, a world_wide trend in science education development in which researchers and science educators set out to describe pupils' ideas about various scientific concept areas such as dynamics, light, heat, energy, electricity etc. These studies revealed that children's idea are very different from those taught in school and that many of them are very robust, being particularly resistant to teaching. Duit (1989) claimed that the rapid growth in this type of research had two origins. First there was the dissatisfaction among science educators with the results of curriculum development of the sixties and early seventies. Secondly, he points to psychology and its move to become "cognitive science", with cognitive psychologists in search of research domains which would not be too narrow, so focusing on science, especially Physics. Thus there was considerable overlap between the two groups, one promoting the other. Duit (1989) also notes that 70% of the educational research in Germany was in physics education.

In the middle 1970s, work in France into students' conceptions in science stemmed from the ministry of Education's investment in a new science curriculum for children from 10 years onwards. Sere and Well _ Barals (1989) give an overview of the French work, which had its origin in Piagetian theory. They claim that Piaget's theory had a triple use: It helped in the development of analysis of children's ideas based on his earlier work of children's conceptions of the physical world, it provided a basis for the interpretation of pupils' behaviour, and it facilitated thinking about didactic interventions, with the accent on manipulation of objects. The French work covered a large number of areas such as electricity, light temperature, heat, combustion, gaseous states, pressures, force and energy, showing, as in the German work, a bias towards the physical sciences. Most of this work in science education took a constructivist view of learning, in which learners are seen as taking an active role in the development of their own idea. Children's ideas were no longer seen as "strong" or "wrong", but as different from teachers' ideas and as important in pupils' exploration of the physical world. (Driver & Erickson, 1983, Gilbert' & Watts, 1983) for overviews; and Driver, Guesne & Tiberghien (1985) for accounts of children's ideas).

2.4.0 Constructivist's Approach to Teaching and Learning Science

Millar (1989) points out that, the "process of eliciting, clarification, and construction of new ideas takes place internally, within the learner's own head".

Specific activities that could be useful for constructivist learning include:

1. encouraging and accepting student autonomy, initiation and leadership (Glassner, 1986);
2. allowing student thinking to drive lessons, shifting to content and "instructional" strategies that are based on student responses;
3. asking students to elaborate in their responses (Doris, 1991);
4. allowing wait time after questions (Rave, 1973);
5. encouraging students to interact with each other and with you. (Whimbey and Lochhead, 1991);
6. asking thoughtful, open_ended questions;
7. asking students to articulate their theories about concepts before accepting teacher (or textbook) explanation of the concepts (Clement, 1987);
8. looking for alternative concepts of students and designing lessons to address any misconceptions (Tager, 1991).

In other words, a constructivist view of learning science takes account of pupils prior ideas about the natural world, either from their own observation or from everyday language, acknowledges that learning will involve developing, modifying and even rejecting existing ideas and accepts that understanding is something learners construct for themselves.

A number of constructivist approaches to science teaching have also been developed (Cosgrove et al, 1982; Biddulph and Osborne, 1984, Driver, 1989; Hurlen, 1992; Appleton, 1993: Novak, 2002). However, they differ a little in detail, can be summarized as follows:
identify students' ideas and views create opportunities for students to explore their ideas and test their robustness in explaining phenomena, accounting for events and making prediction to develop, modify and, where necessary, change their ideas and views support their attempts to rethink and reconstruct their ideas and views. (Hodson, 1998).

2.4.1 The Phases in Constructivist Research

Generally speaking, three distinct phases can be identified in constructivist research.
The early work in the 1970s and 1980s focused on identifying and documenting misunderstandings. This initial work emphasized the patterns in the ideas held by individual learners, hence it is referred to as personal constructivism. (Von Glasersfeld, 1995).

However, there was a shift in focus to what this might mean for teaching by the early and mid 1980s. This period could probably be described as the 'golden age' of constructivist research, when its approaches and ideas were virtually unchallenged. Nonetheless, the late 1980s saw the emergence of writing which was more of certain aspects of the work and an increasingly more theoretical debate on the nature of constructivism and the development of constructivist research. One major outcome of this debate has been a more critical reflection on the messages from constructivist research as a 'mature' area of research for teaching science. The most recent writing has located the constructivist view point within a broader view of learning with a more emphasis on the socio-cultural aspects of learning. Carmicheal et al., 1990 and Pfundt and Duit (2000) listed well over 2000 articles on constructivism and three books providing an overview of studies.

2.4.2 Summary on the Constructivist Approach to Teaching and Learning

A building contractor who sets out to build a house usually knows how it should look and has plans to follow. The contractor lists materials needed, establishes a time line, surveys materials available, and gets whatever else is needed. Before beginning, the contractor checks that the foundation can be built properly. Later, the design may be modified to accommodate structural changes.

Developing, or constructing, a teaching unit can resemble this procedure. The goals and objectives for the students are clearly defined and visualized. Just as the contractor surveyed the materials available, a teacher who uses the constructivist approach may survey the students to learn what they already know about the topic. A teacher can also find out what students already know by allowing them to engage in an exploration activity. The teacher finds out what students went to know by asking them to think of questions they would like to have answered. The teacher gains new insights and before building a layer of learning on a poorly built foundation, can work out any misconceptions students may have.

If the teacher does not learn what students already know about a topic, the class may repeat things they already know or try to build on knowledge they do not have. They will miss opportunities to connect with previous learning and to build foundations for future learning. Just as a contractor may modify the design, a teacher may alter lesson plans and provide activities to meet students' needs and to help them construct new understanding of a topic. These adjustments may detour from the prescribed unit or text, but they can ensure construction of a solid foundation.

Thus "constructivism" gives different answers to the questions of who makes knowledge, how this is done, and on what basis knowledge is held to be knowledge.

Although constructivism is a heterogeneous movement, many constructivists in science education derive their positions either from Piaget, or from Kelly. These two origins lead to quite distinct and different views of "what knowledge is" and these have very different implications for research and classroom practice (Bliss, 1993).

In science education, Pope and Gilbert (1983) use Kelly's ideas to lend support

> …to teachers who are concerned with the investigation of student views and who seek to incorporate these views within the teaching – learning dialogue and who see the importance of encouraging students to reflect upon and make known their construction of some aspects of reality.

Their focus is on the individual and on the uniqueness of each person's construction of the world. Osborne and Wittrock (1985) spell out some of the difficulties that such an approach would present to teachers. For example, it requires the teacher to be diagnostic of each individual's set of constructs. Thus the problem arises as to whether there are as many construct systems as there are individuals, or whether there might be similarities between construct systems in the same way as some children could be seen to have similar personalities. Matthew (2003), concludes that because constructivism is a theory of learning, the characteristics of effective constructivist teaching are not clear.

Constructivism, derived from Piaget or Kelly, does not attribute a sufficient role to the teacher, parent or peer and this has rightly led to attention being given to ideas about the role of the adult or teacher in the pupil's learning. For some constructivists, development precedes learning and is necessary for learning. However, for Vygotsky, psychological development does not precede instruction, but depends on it. Other constructivists draw inspiration from re-interpretations of Piaget, notably Von Glassersfied (1985 - 1989), Von Glasersfied and Wheatley suggest that it follows from Piaget's theory that the real world does not exist, being created by human thought and being dependent upon such thought. Knowledge originates in the learner's activity performed on objects. Wheatley (1991) goes as far as to argue that objects do not lie around ready made in the world but are mental constructs. Bliss (1995) construed this as a total interpretation of Piaget's constructivism, which is plainly realist, with intelligence deriving from real actions on real objects. Matthews (1992) in appraising constructivism, makes it clear that it is often made into an ideology. He argues that it is created as a theory of education with views about children should be treated, how teaching should proceed and how curricula should be developed and implemented.

One of the most common views held about constructivism is that it sees the child as learning about the world through experience. Many science teachers also view this as sensible approach to the teaching of science, with children actively exploring the physical world around them. While this approach is useful on some occasions, science teaching needs also to be seen as the way in which pupils are introduced into the communal world of science concepts and techniques, and communal standards of argument and evidence. Matthews (1992) gives an example: how Galileo changed not the facts but the arguments. Galileo did not see the real objects of science any differently from anyone else. But he did describe them differently and it is these descriptions, the theoretical objects of science, with which pupils have to grapple. The pupil's task in school is to come to terms with the scientific account of the world. While adult scientists can see how the range of different ideas interrelate and fit into a more general overarching theory of science, pupils meet these different ideas in separate contexts which may or may not relate to their own experiences.

Constructivism rarely distinguishes making personal sense of the real world, and understanding the socially constructed world of scientific ideas. Glasserfeld's constructivism reduces all understanding (including science) to making personal sense of the world. Social constructivism reduces all understanding (including science) to learning cultural practices. Neither reduction seems adequate to describe children learning science in school.

2.5.0 The Meaning of STS

Several authors and groups have different perceptions of science/ Technology/ Science (STS). In 1980, the National Science Teachers Association NSTA (1982) as quoted by Yager (1996) described STS as the Central goal for Science Education.

> *The goals of Science Education during the 1980s was to develop scientifically literate individuals who understand how science Technology and Society influence one another and who are able to use their knowledge in their every decision-making. The scientifically literate person has a substantial knowledge base of fact, concepts, conceptual networks and process skills that enable the individual to learn logically. The individual both appreciates the value of science and technology in society and understand their limitation (NSTA, 1982, P.1).*

Further assessment by the NSTA provides a more definite statement: NSTA (1991) defined STS as the "teaching and learning of Science/Technology in the context of human experience" NSTA position statement went on to say that: The bottom line in Science/Technology Society (STS) is the investment of learners in experiences and issues which are directly related to their lives. STS develops students with skills which allow them to become active, responding to issues which impact their lives (p.47- 48.)

Conclusively, "STS means using Technology as a connection between science and society", making the application of science closer to the lives of students including advances and issues concerning food, clothing, shelter, transportation, communication etc.

2.5.1 History of Science/Technology/ Society - STS

Yager (1996) affirmed that STS originated in several European countries. It is a reform movement of the 1960s which started with two National programmes in the United Kingdom and went on for several years. The first of these programmes was "Science and Society" and the second was called "Science in social context". These two programmes were sponsored by the Association for Science Education in the United Kingdom. This reform movement which spread to Netherland and Canada partly has its root in the "concern to promote scientific literacy i.e to make basic principles and methods of science clear and accessible to students whose major interests do not lie with the area of any science" (Vevoulis and Clover, 1970).

In addition, Schrodinger (1970) echoing the thought of other scientists of his time pleaded that the planners of scientific curriculum must develop a scientific understanding of science itself, think about science in new ways.

> *The modern tendency to regard science as somehow apart from, or even dominant over, the main human currents that surround it is dangerous to its continuance, and can be harmful even to progress within science. But as we have seen changes in science in the post have also to be related to change in basic religious attitudes. In, aesthetic perceptions and in social relationships* (pp 72 – 74).

In the 1960s, according to Yager and Temir (1993) the curriculum was centrally developed and the teacher was to use the prescribed materials. It was assumed that if the structure of the discipline was taught with an emphasis on inquiry, students would not only learn the content and inquiry skills but also would use and apply them to everyday life and to problem solving in general. When this happens, continued that school of thought, positive attitude towards science and science learning would occur. However, there was a disappointing realization of the new curriculum potential and because the potential did not materialize, the whole train of expected events did not occur. Most programmes reverted back to coverage and verification of materials. Classes remained boring, rote learning continued to nourish and many students were alienated from science.

STS movement has grown as a result of general feeling of disappointment from the outcome of the curriculum reform of the 1960s. Among the main difference between STS programme and the curriculum reform of the 1960s is the STS focus on the application and use of knowledge, their relevance to the life of individual and to society and the central role of the teacher in curriculum development.

Yager (1996) further shed light on the differences that during the 1960s every effort was made to distinguish between science and technology. Basic science was a focus and technology was stricken from courses labeled "Science". The prevailing view was that science could be made meaningful, exciting and appropriate for all if it were presented in a way known to scientists. There was no chance for student ownership, student questions or student views of the world in which they lived. Rather, the attempt was to get students into the world scene, known and experienced by scientists, that was identified as the major task of the science teacher". On the contrary, STS was Technology as a connector between science and society.

2.5.2 STS Teaching Strategy for the Constructivist Approach

STS is a teaching strategy, that encourages students to take responsibility of their learning, makes teaching dynamic rather than static, and permits the flexibility of classroom activities necessary if students are to construct knowledge. This teaching strategy places emphasis in the process of arriving at an answer, rather than simply

requiring that students be able to regurgitate the "right" answer _ whether or not they understand either the answer or its justification. It is a strategy that allows students time to construct knowledge, this circumventing the pitfall succinctly described by Hawkins (1983), "instruction by a teacher fails without a matching construction by the learner". STS teaching proves an appropriate strategy. An STS teaching strategy focuses n process, not product. This is consistent with constructivist thinking. In order to construct knowledge, the learner must organize new data. This can only happen if the process of generating that data is explicit.

STS teaching by definition provides a context for the information that students acquire, it is the context that drives the search for relevant information; learning is context driven, rather than textbook-driven. This is a characteristic of constructivist approach: allowing student's questions and preconceptions to drive the lessons. STS also addresses student's alternative concept, including, misconceptions, another characteristic of a constructivist approach. For instructors eager to use a constructivist approach, STS provides a teaching strategy that is both effective and flexible.

The six basic steps are:

1. Brainstorm an issue or topic,
2. Define a specific question or phenomenon,
3. Brainstorm resources for obtaining information,
4. Use the resources to collect; information,

5. Analyze, synthesize, evaluate, create and
6. Take action. (Yager, 1996)

These steps do not necessary have to taken in a logical sequence, from one to six. Any step subsequent to step one can feedback into a repetition of any earlier step. Each individual investigating will have its own unique sequence and combination and variations on the themes listed above.

Nonetheless, the STS has been criticized for not teaching students the science content they would have learnt through a more traditional approach. According to Gallagher (2004), this criticism should not be directed at the approach itself, but at the considerable variation in the clarity of teachers' goal for project-based science experiences.

2.6.0 Some Teaching Models

The Tool Kit at Rijnlands Lyceum

The Tool Kit was developed in Quebec by Jacques Robitaille in 1991, a pedagogical consultant. Originally written in French the document has been translated into English.

The concept of a "Tool Kit" implies a set of tools/strategies that can be taught to students and then used by them as instruments towards becoming more effective learners. According to Robitaille (1991). We used the title

> *The Tool Kit because a carpenter ,a plumber and a mechanic need tools to do their work and well organized box to store them in studying,taking notes doing research, etc, are also tools -- intellectual tools. Your brain is your tool kit.It's up to you to fill it with all the tools that may be necessary. The more tools you have in your brain, the better you will be able to do the job. These intellectual skills will help you be successful In school. .... (pp 4).*

The Kit is divided into a number of levels and modules covering grades 6-10 (11-15 years old). Themes introduced at the lowest level are usually repeated in later years with more complex skills being developed. For example Module I of levels 1, 2 and 3 of the programme are given the title "Getting Organised". Level I introduce basic organisational and study skills (improving the appearance of work, organising a loose leaf binder, using an agenda, planning). Level 2 develops some of these further (making a work schedule, managing school work). Level 3 examines more closely the effective use of time. A summary of the contents of the tool kit, level 1-3 is provided in Table 2.1.

The material is largely presented "context free" and it is left up to the teacher and student to make connections with the content areas. The text is easy to follow and written for student (Table 2.2). The material deals with learning and study skills ranging from "lower level" Organizational and social skills to "higher level" cognitive skills such as evaluation and synthesis.

How the Tool Kit Was Used in Rijnlands, Lyceum

(1) Students at Rijnlands are given a copy of the Tool Kit to keep. Homeroom teachers decide which modules are taught and in what order. Subject teachers are able to influence this decision by requesting that 'urgent emphasis' be given to a particular skill in the case of a group of students who have a particular weakness.

(2) Students have an input as well and influence the sequence and scope of the programme through class discussion. Homeroom teachers expect support from subject teachers in reinforcing and developing specific skills.

(3) The style of the tool kit is to offer different learning skills and strategies while making it clear that a particular skill is only one way of approaching learning. Students are taught skills but at the same time are encouraged to be critical of them. No attempt is made to force students to use a particular strategy. The emphasis is on learning a number of strategies, thereby increasing awareness and choice.

(4) For example, in teaching note taking, two possible strategies are offered, outlining and mapping (Table 2.2). Various exercises follow the descriptions enabling students to practice what they have learned. In class, students are encouraged to discuss how useful they find a particular strategy. Teachers in the content areas are expected to know about how the 'Tool Kit' deals with note taking and are encouraged to reinforce it in their lessons.

Table 2.1 The Tool Kit Summary of Themes and Content Levels 1 - 3

Level 1	Level 2	Level 3
Getting Organised Presentation, organizing a loose-leaf binder, using an Agenda, Planning an Activity, Working environment, Developing good study habits.	Making a work schedule, Managing school work.	Managing time.
Following a Lesson Active Listening following Instructions.	Knowing how you learn, listening problems, listening to a presentation and identifying main points.	Recognizing digressions in a presentation, taking short notes.
Learning More Efficiently Efficient reading, outlining and mapping notes, improving memory and vocabulary, studying problem solving.	Asking relevant questions, dealing with abstract concepts, a method for reading a long text, improving memory and vocabulary, working out possible causes.	Decoding text-asking relevant questions, summarising, reading speeds, improving memory and vocabulary, solving problems.
Tests and Examinations Stress, structure of tests, nature of tests.	Planning for an exam.	Writing long answers.
Research Using a Library, how a book is organized, doing simple research.	Choosing a subject, finding information, plan, organizing information.	Periodicals, making a hypothesis, outline, looking for information, selecting information.
Communicating Results Writing an introduction, paragraph, conclusion, bibliography, presenting results.	Using visual aids, writing more effectively.	Quotations and references, making a poster.
Participating in Group Work	Different types of meeting, group work	Contribution to a meeting styles of participation.

Fellowship Project for the European Council of International Schools. 1996

Table 2.2

Example of the style of the Tool Kit

The Tool Kit Module 1 Wrapping It Up With Notes

Taking Notes While Reading

Your first question may be, 'How do I decide what I'm going to take note on? I understand how you feel. Not all adults know how to take notes either. It is a skill that has to be learned.

First, you need to know why you should summarize

- To keep important information
- To give you a better outline of the ideas that are linked one to another. This need not be done for all long texts.
- To review a lesson for a test or an exam; a summary can be read more quickly than a complete text.
- It will help you remember information

Procedure

1. Use your active reading skill while surveying and reading, ask yourself the usual questions:
    - What is the next about?
    - What is the main idea?
    - What elements reinforce the main ideas?
2. Now that you have located 'the main idea' and 'the significant element, ask yourself the following questions:
    - What do I have to remember?
3. Choose a note-taking technique that suits you. We will suggest two ways to take notes in this unit:
    - Outlining
    - Mapping

Fellowship Project for the European Council of International Schools. 1996

Comments on the Tool Kit

The Tool Kit provides a written curriculum for developing learning skills. Learning skills and examples of good practice are listed and explained so that teacher and administrators do not have to develop their own materials, an important point in schools where staffs are already working to full capacity. Furthermore, the curriculum is explicit and easy to see. The modular approach of the course makes it easy to select (and reject) materials. The kit's resources can also be used in conjunction with other study skills courses and does not have to be taught regimentally from beginning to end.

While the Tool Kit presents different ways of approaching learning, the selection is limited. Strategies for learning more effectively are presented that may not be helpful to student with different learning styles. This can be partly avoided, as previously mentioned, by thoughtful teachers who use the Kit as an agenda and model for discussing ATL rather than treat it as a text to be learned.

The programme does not start from what teachers and students are doing in the class, using this as a basis for developing learning skills. It attempts to develop learning skills as a parallel curriculum. The danger here is that teachers may not like or agree with the treatment of particular skills in the kit. The number of options given students, as well as the nature of the options, is limited.

The Kit is more effective at developing "lower level" organizational skills than higher cognitive skills. The material covered in the course mostly deals with the former. Successful implementation of the programme requires homeroom teachers with the necessary time and experience to act as ATL teachers. As with other approaches, subject teachers must be willing to reinforce the Tool Kit skills and spend class time doing so.

2.6.1 The Spindle/Spiral Model at the Vienna International School (VIS)

M. Davis and C. Ellwood, considering the best way to develop Approaches to Learning at the Vienna International School, developed a model in 1989 that they named the Spindle/Spiral. One concern influencing Davis and Ellwood's thinking was how best to develop a programme that would meet the needs of a very diverse student body. The Vienna International School serves the United Nations, diplomatic and international business communities in Vienna and has approximately 1,600 students Kindergarten through 12th grade. Students come from about eighty different nations and stay at the school for varying lengths of time. The consequence is that students have diverse cultural backgrounds, very different cognitive styles and are usually working in a foreign language. Some students do not have a singular mother tongue although they may speak several languages. Davis and Ellwood recognized that in such a setting an ATL programme needed to be open and flexible, allowing for different starting levels and rates of progress.

Davis and Ellwood noted, when reviewing skills lists generated by teachers that the same ATL skills kept reappearing both in different subjects and the same subject in different years. This gave rise to the idea of a spiral. In this model learning skills are developed in the content areas. The starting point is for each teacher and department to identify the ATL skills they teach a particular grade level. It will 'be the case that many of the same skills reappear requiring more advanced treatment as student progress up the school. Once identified, the skills are covered in the subject areas. These skills are made known to other teachers, and student and parent. Overlap between subjects is identified through grade level teachers meetings which are used to help 'build bridges' between the content areas. Teachers meet and discuss both the aims and strategies of their course and the progress individual students are making. One focus for ATL therefore becomes the year level meeting. In this way students develop learning skills at their own pace through the subjects areas. Themes, introduced at lower levels are repeated and developed in latter years. Allowance is made for different styles. Diversity rather than homogeneity is expected.

The "spindle" at the beginning and end of the programme (Tables 2.3) represents the allocation of time specifically for ATL. In the first year of the programme students have a lesson a week as part of the established core curriculum in English and Humanities. This lesson deals with the basic organizational and social skills. These are seen as being more transferable and universal than higher cognitive skills and therefore more amenable to being taught in separate lessons. In the last year of the programme (the second 'bulge' in the model) the emphasis is more on metacognition than study skills. Time is taken out from the weekly curriculum for special projects given the collective name 'Applications of knowledge'. In years two, three and four of the programme no extra time is allocated on a regular basis for ATL although themes are introduced to focus attention on ATL.

Also, themes are used to help focus ATL development in the subject areas and through special workshop days in which the timetable is suspended. Initially each grade level at VIS was given a different theme. Following an introduction to "Learning How to Learn" in year one of the programme, focusing on study skills, year two developed the theme of "communication skills". Aspects of "communicating", (written, oral, writing up research) were considered. In year three and four the theme became "Thinking strategies".

The final requires students to focus on "Applications of knowledge". In one session students, working in groups, were required to list the skills they thought they learned in a specified subject. These were compared to the lists that teachers had made leading to a discussion over the nature of skills in different subjects. The lists that students came up with were circulated to all departments so that teachers could see if the students' perceptions matched their own. While it was recognized that being able to recognize and discuss the skills did not mean that all students would be successfully able to practice them, the point was to take time to reflect on learning. The nature of ATL in this, the last year of the programme, is similar to Theory of knowledge in the IB programme. In recent years the school has moved away from different themes for different grades towards a common theme across all grade levels, which changes each year. In 1995 the theme that was decided was Values.

Comments

The Spindle Spiral Model is more of a framework than a methodology unlike the Mercedes Model which is an instructional model. The content of an ATL course is not prescribed, individual subject teachers define their ATL goals, communicating and coordinating these with other teachers through grade level meetings. The emphasis of this approach, according to Davis, is on improving teacher practice through raising awareness about ATL: 'the programme at VIS is not so much student oriented as teacher oriented. It tries to raise teachers awareness of how to improve student learning'.

The Spindle/Spiral model is based on a number of principles.

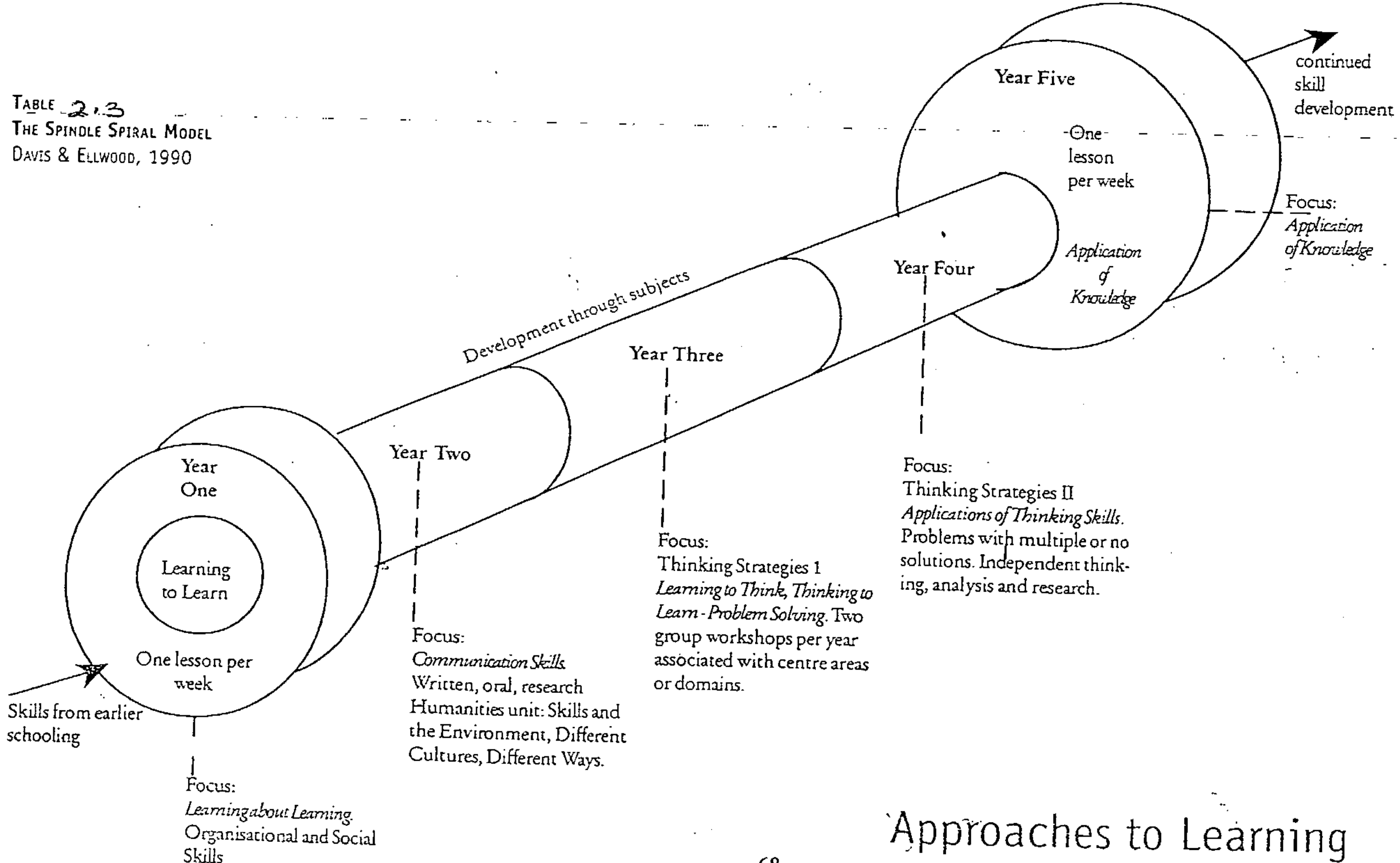
1. ATL should permeate the whole curriculum and be developed in all content areas.
2. Because students learn in so many different ways and at so many different levels in terms of the learning skills they already posses at VIS, a flexible approach to ATL is needed.

3. Students need to discover how they best learn. It is the school's responsible to create an environment in which this can best happen.

4. Teachers have to learn how they teach learning skills and improve on this practice. While teachers are in effect already doing this in class most are not sufficiently aware of what they are doing. Greater awareness will bring the possibility of conscious control and development.

The main disadvantages of this approach are in the discretion it gives to individual teachers. It is absolutely essential that tokenism is avoided through the explicit discussion and articulation of ATL. The co-ordinator responsible for ATL, other area leaders and teachers need to have regular contact.

TABLE 2.3
THE SPINDLE SPIRAL MODEL
DAVIS & ELLWOOD, 1990



2.7.0 Gender Issues in School Sciences

What is Gender?

Gender is a psychological and cultural term, referring to one's subjective feeling of maleness or femaleness. (Gender identity). Gender may also refer to society's evaluation of behaviour as masculine or feminine (gender role). The degree to which a person identifies with societal definition of masculinity or femininity is referred to as gender role identity or sex typing. Gender is distinguished from sex, which involves the biological dimension of being female or male. Gender also refers to the economic, social and cultural attributes and opportunities associated with male or female (UNFPA, 2002).

Views on Gender Development

There are three ways to view gender. One way is to stress biological factors in the behaviour of males and females, another way is to emphasize the social influences or the cognitive factors.

Biological Views

In humans the 23rd pair of chromosomes determines whether the foetus is a female (xx) or a male (xy). Gender experts with a strong environmental orientation acknowledge that girls and boys are treated differently because of their physical differences and their different roles in reproduction. Some biological approaches address differences in the brains of females and males (Eisenberg, Martin and Fabez, 1996). One approach focuses on differences between females and males in the corpus callosum, the massive band of fibers that connects the brain's two hemispheres. Other approaches emphasize variations in the left and right hemispheres of the brains of males and females. Presently, there are controversial views. What is well known is that the brains of females and males are far more similar than they are different.

Socialization Views

Both identification and social learning theories describe social experiences that influence children's gender development. Identification theory stems from Feud's view that the pre-school child develops a sexual attraction to the opposite-sex parent. Then, by about 5 or 6 years of age, the child renounces this attraction because of anxious feeling. Subsequently, the child identifies with the same sex parent, unconsciously adopting the same-sex parent's characteristics. Today, most gender experts do not believe gender development proceeds in this way. The social learning theory of gender emphasizes that children's gender development occurs through observation and imitation of gender behaviour, as well as through reinforcement and punishment of gender behaviour. Eleanor Maccoby (1997) who has studied gender for a number of decades, believes that peers play an especially important gender-socializing role, teaching each other what is acceptable and unacceptable gender behaviour.

Cognitive View

The two cognitive views on gender are (1) cognitive developmental theory and (2) gender schema theory. According to the cognitive developmental theory of gender, children's gender typing occurs after they have developed a concept of gender. Gender schema theory states that an individual's attention and behaviour are guided by an internal motivation to conform to gender-based socio-cultural standards and stereotypes.

2.7.1 Research on Gender and Science Education

A well known nineteen-century nursery rhyme by J. O. Halliwell goes like this:

What are little boys made of ?

Frogs and snail and puppy dog's tails

What are little girls made of ?

Sugar and spice and all that's nice.

This rhyme implies there are differences between boys and girls. Are any of them valid? Issues on real and perceived gender differences can be vital to effective teaching.

For over two decades now a strong tradition has been established in research on gender issue in the science classroom. This is due to both serious and justifiable concerns about the gross under-representation of girls in science and the number and contribution of women in science and technology careers. The concerns about this under-representation are generally economic (world of work) social and philosophical (relating to equity and equality).

A comprehensive review of literature on gender differences reveals that the factors which have been found responsible for the gender imbalance in science could be grouped into six broad categories.

1. Individual factors (American Association of University Women) (AAU 1992). (Baker and Leary 1995).
2. Cognitive factors (Adelman 1991, Forrest 1992)
3. Attitudinal factor (Catsambia 1995, Rennie and Punch 1991)
4. Home and family factors (Simpson and Oliver 1990)
5. Educational factors (Baker 1990, Tobin et al. 1990)
6. Socio-cultural factors (Jegede and Okebukola 1992, Udeani 2000).

It has been reported that in the U.S.A women constitute only 16% of all employed scientists and engineers while 30% and 21% of the degrees awarded at the bachelor's an doctorate degree in natural science and engineering respectively go to women (Vetter 1990).

In Nigeria, the picture is even more depressing. The Science Teachers Association of Nigeria (STAN 1992) reports that less than 10% of the total enrolment in Nigeria Universities for science and technology, based disciplines are females, only 6% of those who enrolled in West African and the Senior Secondary School Certificate Examinations are girls and less than 5% of the academic staff in Nigerian Universities engaged in science-related disciplines are women. This must also be weighed against the fact that females make up about 60% of the country's 100 million inhabitants. Less than 30% of the 1,000,000 girls in secondary schools take science subjects. Also, WAEC reports on Senior School Certificate Examination (SSCE) from 1998 to 2004 have shown that percentage entries and performance at credit level of girls in SSCE (private and public) in the physical science, mathematics, technical drawing, introductory technology are low compared to that of boys (UNESCO – UNICEP, 2006)

Udeani (2000) in Nigeria reports that:

(1) Female enrolment thins out as you move up the educational hierarchy.

(2) There are fewer women than man enrolled at University courses in science.

According to her, one of the most indisputable facts is that the world is characterized by gender unbalances in literally all facets of life, education inclusive. Several researchers have equally exposed a series of gender disparities in education (Abagi 1997, Wamahiu

1998; FAWE 1997) and gender concern in education has been identified to cut across all levels of education but perhaps two particular level that has experienced marked gender inequalities in higher education, science and technology. Empirical studies worldwide now show that female students are grossly under-represented in science and technical education (Kerre 1996, Alele Williams 1987). Studies in Nigeria have observed that men still end up being the top policy makers, planners and administrators at all senior level with the result that gender balance is very much skewed to the advantage of men. (Alele Williams 1987).

Udeani, (2000) lists some factors responsible for low female participation in education in Nigeria. They include:

1. **Socio-cultural Related Problems**

   The socio-cultural setting in many Nigerian societies prohibit the investment in education for girls. They are rather looked at as home makers, wives and mothers and engage in family chores like cooking, taking care of younger sibling, hawking to supplement family income etc while boys playing and study. This puts the girls at a disadvantage resulting in poor academic performance and eventually dropping out. Early managers are also arranged for young girls they hardly finish their 10 education.

2. **Economic Related Problems**

   In recent years parents have got to pay fees for the children in school because of the economic problem facing the government in most states in Nigeria. Faced with economic hardship, many parents prefer to send their boys to school than girls for their claim to be unable to pay fees.

3. **Inaccessibility to Schools and Inadequate Infrastructure**

In some rural communities in Nigeria, a child may have to trek a distance of 10km to get to school. When faced with such hardship, girls are the first to drop out because they are not able to overcome the frustrations encountered on the way. Poor infrastructure in terms of classroom, furniture and other school facilities like the convenience worsen matters with girls especially when they are menstruating and need some privacy.

Gender Bias in the Curriculum

Girls tend to drift or are guided towards areas of study regarded as Feminine. These observed marginalization and discrimination against women all over the world came to be summarized by the UN in the following words.

(i) Women perform 2/3ths of the world's work

(ii) Women earn 1/10th of the world's income

(iii) Women are 2/3ths of the world's illiterate

(iv) Women own less then 1/100th of the world's property

This situation compelled the UN to hold conference, pronounce declarations and embark on programmes to redress the imbalance as well as set up international agenda aimed at promoting gender equality in all spheres of life. Prominent among the conventions and declarations are:

(i) The Nairobi Forward Looking Strategies for the Advancement of Women (1985).

(ii) The Convention for the Elimination of all forms of Discrimination Against Women (CEDAN).

(iii) The Beijing Declaration and Platform for Action (1995).

Also, the world conference of 1990 on Education for All which took Place in Jomtein took up the issue of scientific and technological literacy for all. A concrete follow up to the conference was the project 2000+ in which emphasis was made to ensuring the scientific and technological literacy of women.

A Summary of Key Research Findings on Gender and Science Education

- The girls and science problem originally identified in the 1970s and 1980s was one in which girls were under represented in the physical science and boys' achievements in these subjects were superior to those girls.
- Currently, fewer girls than boys choose physical science subjects, particularly physics but girls now outperform boys in most science subjects except physics.
- There is no evidence to suggest that girls and boys have any significant inherent differences in ability.
- Boys generally have a more positive attitude to science than girls and the masculine image of science has a strongly alienating effect on girls.
- Girls' confidence and levels of achievement are likely to increase when single-sex teaching groups are used in science. There do not appear to be similar benefits to boys.
- Measures of performance are dependent on the assessment strategies employed, with girls doing particularly well when assessment involves course work and project work.
- Strategies aimed at increasing girls' participation in science are effective in increasing girls' (and boys') interest in science lessons, though have not had significant impact overall on levels of participation. Impact has been greatest where strategies have been implemented in situations where there is a more general commitment to ensuring equality of opportunity.

- Researchers with a particular interest in gender issues argue that a radical reconstruction of science is necessary so that it reflects females' contributions and attributes, leading to a gender-inclusive curriculum which appeals to both girls and boys.
- The views, actions and classroom practices of teachers have a critical influence on girls' (and boys') involvement and achievement in science. (Bennet, 2005)

The Way Forward: Closing the Gender Gap

Udeani (1999) highlighted ways aimed at closing the gender gap.

1. **The Universal Primary Education (UPE) and Universal Basic Education (UBE) Programme**

   The introduction of the Universal Primary Education Scheme and the Universal Basic Education Scheme by the successive government in Nigeria is aimed at giving every Nigerian child irrespective of sex equal opportunity to formal basic education the first nine years of schooling. The scheme provides free, compulsory UBE for every Nigerian child of school going age. This scheme should be backed up with appropriate and stiff legislature law to prevent parents from withdrawing their girl children from school for various reasons.

2. **The Federal Government Unity Schools**

   The Federal Government through its unity school project established an all female secondary school in each state of the federation targeted towards increasing female enrolment at 20 school level.

3. **Quota System in Tertiary Institutions**

   Lowering of entry requirement for girls for some courses, which do not ordinarily enroll girls, has been highlighted by Andam (1999) i.e the University departments should take girls with minimum qualification without necessarily having to compete with boys for places.

4. **Informative Campaigns**

   Education campaigns to encourage girls stay in school and parents to have fewer children should be put in place. In SMT area, campaigns on scientific and technical occupation should be carried out.

5. **Economic Relief**

   - Poor parents to pay school fees in installments
   - Parents and girls to do self help projects to make more money for girl education
   - Girls scholarship schemes should be provided

6. **Curriculum Issue**.

   Curriculum should be gender sensitive, more females in core development. Pre - and in service training for teachers on gender sensitive methods of teaching.

7. **Large nationwide government** - funded project such as (JETS) Junior Engineers Technologists and Scientist should be enhanced to popularize increase female participation.

8. The establishment of science, math and technology clinics SMT for girls.

9. Career counseling

10. Scientific Awards and Prizes targeted towards females

11. Science fairs

The present study would determine the extent to which gender affects students knowledge, understanding and application of biology concepts: thereby contributing to the extensive research findings on gender.

Implications of Research in Gender and Science for classroom Practice

- Teaching resources should be surveyed for gender bias and such bias should be removed or openly challenged where removal is not possible.
- Teaching resources should ensure that the contributions of both male and female scientists to the development of scientific knowledge are acknowledged.
- Appropriate personal experience, contexts and science-related social issues should be used as the starting point for developing scientific ideas as these are likely to increase both girls' and boys' interest in science.
- A range of activities should be used in science lessons to ensure appeal to both girls and boys. Girls tend to do better at interactive, collaborative activities which draw on linguistic and imaginative abilities.
- A range of assessment strategies should be employed to ensure that no one strategy which favours either boys or girls predominates.
- Teaching pupils in single-sex groups should be approached with caution and seen as one possible strategy in a more wide-ranging review of a school's curriculum and classroom practice.

2.8.0 Educational Reforms and the Role of Assessment

The comparative dry enterprise of measuring student attainment of academic outcomes has become the concern and focus of considerable attention as a mechanism for commencing changes in what and how students learn. According to Airasan, 1988, Geiger, 1991; Heyneman and Ranson, 1990; educational reforms have consistently and increasingly relied on assessment to obtain their objectives, to substantiate their contentions or to promote implementation of their innovation.

Educational reformers are joined by lawmakers, who always incorporate an assessment framework or mandate an evaluation component into new legislation. However, at the centre of the assessment revolution are teachers and those with concern about the information needs of classroom teachers. Assessment reform has been considered to be the foundation of general educational reforms. Consequently, revived interest in assessment has exceeded reasonable prediction.

2.8.1 What is Assessment?

Assessment is undergoing a paradigm shift from psychometrics to a broader model of educational assessment, from a testing and examination culture to an assessment culture. However, four definitions of assessment are seen in current literature dealing with assessment. To some educators, assessment refers to new formats for gathering information about students' achievement. To others, assessment refers to a new attitude toward gathering information. The term assessment also represents a new ethos, one of empowerment, in which assessments are designed and implemented primarily to serve the information needs of students and teachers.

Finally, assessment has been used to refer to a new process, often with medical or psychological connotations, as in the gathering and synthesizing of information about a person that a physician or counselor would conduct as part of diagnosing and treating the person's condition. In spite of the definitions above, many researchers and practitioners concur that notions about assessment need to be broadened. (Baker and Stites, 1991; Cizek and Rachor, 1994; Ferrara and McTighe, 1992; Stiggins, 1991a).

Airasan, (1994) presented examples of what a broadened conceptualization might look like. According to him, assessment should include "the full range of information teachers gather in their classrooms; information that helps them understand their pupils, monitor their instruction and establish a viable classroom culture. Baker and Stites (1991), also envisioned formal student assessments of cognitive and non-cognitive characteristics, in which "students will need to demonstrate their commitment to task over times their workforce readiness and their social competence in team or group performance contexts" (p.153).

Second, it would be beneficial for a definition of assessment to convey an attitude that enhances the position of assessment in instruction.

Third, a definition that recognizes that assessments should serve as oppose to drive, instruction would be preferable.

Finally, a definition of assessment should provide a link to educational processes that seek the welfare of each student. Incorporating the proceeding facets into a single definition of education assessment yields the following proposed definition. Assessment: The planned process of gathering and synthesizing information relevant to the purposes of discovering and documenting students' strengths and weaknesses, planning and enhancing instruction or evaluating progress and making decisions about students, the process ,instrument or method used to gather the information.

2.8.2 The Purposes of Assessment

Gipps and Stobart (1993) provided a more detailed description of the purposes of assessment in terms of six possible purposes for which it might be used. These are: screening (testing groups of pupils to identify those who may need special help); diagnosis (using tests to identify individual pupils' strengths or more usually weaknesses); keeping (recording scores on tests); feedback on performance (using assessment results to provide information to a variety of groups); certification (to provide qualifications which signify particular levels of competence or knowledge); selection (to identify selected pupils who are capable of the particular levels of competence and performance required for a possible next step, such as University entrance).

Gipps and Stobart suggested that one way of classifying these six purposes is the extent to which they are professional or managerial. A professional assessment is one which helps teachers in the process of educating their pupils, whereas a managerial assessment is one which is associated with accountability and managing in the education system. In addition, Stobart and Gipps (1997) have described the professional and managerial purposes of assessment as assessment for learning and assessment of learning. However, the most common way of characterizing the purposes of assessment is to distinguish between formative and summative assessment.

Table 2.4 Characteristics of Summative and Formative Assessment

Summative Assessment	Formative Assessment
Takes place at the end of a teaching block.	Takes place during teaching.
Aims to measure and report on learning outcomes in order to make a variety of comparisons	Aims to establish progress and diagnose learning needs in order to support individuals.
Uses formal methods	Uses both formal and informal strategies
Is a well-established and traditional form of assessment	Is a comparatively recent development in assessment
Is associated with accountability	Is associated with pupils' educational development

Judith Bernett (2008) Teaching and Learning Science

Summary of Key Research Findings on Assessment

- Although comparatively little formative assessment is used in science lessons, there is evidence to indicate that the use of such assessment raises standards.
- Teachers who have made use of a range of formative assessment strategies in their lessons report benefits in terms of pupils' learning and motivation.
- Incorporating formative assessment strategies into teaching requires significant changes to current practice.
- A curriculum dominated by an assessment model used for the purposes of accountability results in curriculum backwash: teaching becomes led by preparation for assessment.
- The use of criteria referencing may help pupils appreciate the standards for which they are aiming but may also have the effect of reducing a curriculum to those aspects which can most easily be specified and therefore assessed.
- Teachers are able to make reliable and valid assessments of their pupils for the purposes of summative assessment.
- Assessment models which re-interpret formative data for summative purposes are likely to yield invalid data.
- There is evidence to suggest that pupils' performance in tests improves when feedback on their work no longer includes grades but takes the form of constructive written comments.
- The validity of 'league tables' of the performance of schools in national tests has been questioned, leading to the incorporation of measures of 'value-added' to show the contribution a school makes to the improvement in pupils' performance.
- A variety of factors make the undertaking and interpretation of international surveys of performance problematic.

2.8.3 Does Summative Assessment Raise Standards?

'Standards' is a word which is frequently used in educational contexts, most usually in relation to pupils' performance in tests, which in turn is used as indicators of standards of teaching. The justification for the attention being paid to standards has arisen from a general perception that standards are falling. Consequently, steps need to be taken to reverse this decline. To put it bluntly, improving standards is seen as making the education system accountable to those who provide the financial support, many of whom are tax-paying parents.

Bangert-Drowns et al. (1991) reviewed forty studies on the use of classroom testing with a view to establishing the optimum frequency for using tests. Their meta-analysis showed that pupils' marks generally improved as tests were administered more frequently -though only up to a certain frequency before performance started to decline and that several short tests had a more positive effect on performance than fewer longer tests. Black (1993) also reports on the findings of a number of studies which indicated that pupils' learning was improved in a variety of contexts through the use of written questions.

2.8.4 Problems with Summative Assessment

It is clear from the foregoing discussion that summative assessment in spite of its extensive use has its limitations and problems. Findings from a number of studies, Black (1993:52) identified a number of problems associated with summative assessment:

- Science is reduced to learning of isolated facts and skills;
- the cognitive level of classroom work is lowered;
- pupils have to work at too great a pace for effective learning;
- in particular, ground being 'covered' by a race through the textbook;
- much teaching time is devoted to direct test preparation;

- pupils' questioning is inhibited;
- learning follows testing in focusing on aspects that are easy to test;
- laboratory work stops unless tests include laboratory tests;
- creative, innovative methods and topical content are dropped;
- teachers' autonomy is constrained and their methods revert to a uniform style;
- teachers are led to violate their own standards of good teaching.

These problems have resulted in an increasing interest in the possibilities offered to teachers and their pupils by formative assessment.

2.8.5 Formative Assessment

In recent times, much of the writing on assessment has been concerned with the role of formative assessment and the way in which it might improve teaching and learning.

The central feature of formative assessment is that it involves gathering information which is used in the short term to modify teaching and learning. Black and William (1998a) summarize formative assessment as:all those activities undertaken by teachers and by their students in assessing themselves, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. Such assessment becomes 'formative assessment' when the evidence is actually used to adapt the teaching work to meet the needs (p.2; italics in original).

The emphasis here, is given to the role pupils, as well as teachers, might play in formative assessment. Sources of information which can contribute to formative assessment include: Pupils' class work, pupils' homework exercises, dialogue with pupils during lessons, informal tests set during teaching and end-of-topic tests. Some of this information may be generated by pupils engaging in self or peer assessment of their own work.

Formative assessment does have a diagnostic component and may sometimes be referred to as 'diagnostic assessment', though this latter term is often used in science education to describe techniques employed to gather information on pupils' ideas and understanding in topics where they are known to have difficulty, that is as a first step in constructivist teaching.

2.8.6 Research Evidence into the Use and Effects of Formative Assessment

Extensive review of research studies on formative assessment has been undertaken by Black and William (1998b). Two areas explored in the review were the extent to which formative assessment was being used in teaching and its effects on standards. The review revealed that relatively little formative assessment was being routinely undertaken in teaching. For example, a survey of 100 secondary schools in England (Daws and Singh, 1996) indicated that the principal method of teacher assessment in science lessons was end-of-topic tests, (summative assessment) with fewer than a quarter of teachers drawing on dialogue with pupils, a key element of formative assessment, to assess pupils' understanding. Similar findings were reported from a number of other countries, including Australia, England, Scotland and the USA (Black, 1993; Black and William, 1998b).

Formative Assessment and Standards

Black and William (1998a; 1998b) in their study, concluded that there was evidence in the studies they reviewed to suggest that formative assessment does raise standards of performance, particularly for lower-attaining pupils despite the lack of use of formative assessment in practice. Some of the studies reviewed (e.g Butler, 1998) demonstrated that pupils' performance in tests improved when feedback on their work no longer included grades but took the form of constructive written comments. Pupils' self-esteem and motivation were also reported to have improved. The review also enabled them to identify a number of difficulties associated with introducing effective formative assessment into classroom practice. These include encouragement of more learning through teachers' use of tests, lack of discussion between teachers over the nature and purposes of questions used in assessment, over-emphasizing marks and grades at the expense of giving advice and use of approaches which involve norm rather than criterion referencing with a consequent demotivating effect on lower attaining pupils.

2.8.7 Using Formative Assessment in the Classroom

Although some empirical evidence (Bell and Cowie, 2001; Black and William, 1998; 2004, Shephand, 2000), suggests that formative assessment leads to increased learning how these formative assessments are designed, developed, embedded, and eventually implemented by teachers is poorly understood. Bell (2000) asserts that one of the problems with formative assessment arises from the lack of research into the process of what goes on in classrooms where formative assessment is being used. Drawing on observation data gathered in a study undertaken with teachers and pupils in upper secondary science lessons in New Zealand (Bell and Cowie, 1999), Bell, however, distinguishes between planned and interactive formative assessment. The former, as its name suggests, relates to assessment activities the teacher planned to include in their lessons, whilst the latter emerged from unplanned teacher-pupil interactions. She goes on to identify a number of essential features of formative assessment, including the need for planning, the importance of acting on information elicited from pupils, the need to develop a learning partnership between teachers and pupils and the key role of language in helping teachers and pupils describe and negotiate meanings. Another typology of formative assessment has been developed on the basis of research in primary classrooms (Tunstall and Gipps, 1996; Stobart and Gipps, 1997). Essential features of this typology include the need for positive feedback related specifically to criteria and clear guidance on goals or ways of improving the work.

It is evident from literature that the incorporation of formative assessment strategies into teaching requires more than just 'tinkering' with current practice. Daws and Singh (1999) suggest that the successful practice of formative assessment requires:... fostering collaborative, democratic discussion that critically appraises the process of learning and assessment, helping pupils monitor their learning against clearly-specified learning objectives, supporting pupils in taking some responsibility for managing their learning... (p.78)

A comparatively recent development in formative assessment is the use of pupil self or peer assessment. Assessment of this nature, can take a variety of forms, such as pupil sheets incorporating 'can do' statements, pupils marking informal test and pupils designing questions to test understanding. A number of small-scale studies on the use of such strategies in science lessons have reported benefits to both pupils and teachers arising from such strategies (e.g Fairbrother et al., 1995; Daws and Singh, 1999; Black and Harrison, 2001). Benefits cited include pupils gradually gaining a better perception of what makes a good question to test understanding after developing and trying out questions of their own, improving pupils' clarity of explanations, both verbal and written and improvements in performance on end-of-topic tests.

Inspite of the appeal of formative assessment, and the benefit ascribed to it by those teachers who have taken steps to include it in their teaching, it is certainly the case that formative assessment makes considerable demands on time - time for planning how it should be incorporated into lessons as well as time in lessons to make use of formative assessment strategies. Black and Harrison (2001) observed that it took six months for the teachers involved in their study in six schools to move from isolated attempts at using formative assessment in their lessons to developing more formal policies on the use of formative assessment.

Nonetheless, all the teachers felt that time spent on developing and using formative assessment strategies was worthwhile in terms of the benefits to both themselves and pupils.

Implications for Practice

Research has helped to identify some implication of assessment for practice. These are as follows:

Teachers need to be provided with training and time to help develop skills associated with formative assessment and to plan strategies for its incorporation into their teaching.

Whilst teachers clearly have to conform to the external summative assessment system which is in place, care should be taken to ensure as far as possible that pupils' learning is not adversely affected by assessment-driven teaching, with good practice being curtailed in order to prepare for summative assessment.

Feedback to pupils on their work should make less use of grades and concentrate on providing pupils with comments on what they have achieved, directing them to next steps and giving pointers for possible improvement, former inevitably leads to a style of teaching which is incompatible with the latter.

The assessment of learning achievement is changing as world wide reforms, particularly in science education. promote the shift from traditional teaching for lower – order thinking skills, to higher-order thinking skills. (Barak 2007; Tobin et al. 1990; Zohar and Dori 2003).

Also, the literature on assessment is currently promoting the use of formative assessment strategies in Science teaching Educational research should centre on exploring in more detail the contribution formative assessment might take to improve science teaching. This is one of the purposes of this study which would investigate the effectiveness of Mercedes Model (MM) with Embedded Assessment Strategy (EAS) on Senior Secondary School Students knowledge, understanding and application of biology concepts.

2.9. 0 Subject Specializations

Subject Specialization has been a very important factor in the determination of students' achievement. For instance, science students and their non-science counterparts have different ability levels. Mansaray, Ajiboye and Audu (1998) in their investigation of Nigerian teachers' environmental knowledge and attitude classified the teachers along science, arts, and commercial. They found that the science teachers obtained higher knowledge and attitude scores than their arts and commercial counterparts. Hence, this study will investigate further the effect of subject specialization on students' achievements in Biology.

Summary of the Literature

Reviewed literature shows the effectiveness of mastery learning strategy but is not without deficiencies (Bangert, Kulik and Kulik 1983, Kulik et al, 1990, Schunk, 1996) hence, the need for Mercedes Model Instructional strategy (Gallagher, 2000).

Mastery learning strategy recorded certain degree of success (Adepoju, 2002; Akinsola, 1995; Ajeusi, 1995, Igbekwe 1995) but it was without proper feed back mechanism. Consequently, the need for a continuous formative and embedded assessment strategy as it is used in this study. Mercedes Model with Embedded Assessment Strategy adopted and modified in this study is an aggregate of all the twentieth (20th) century theories including Constructivism and Science Technology and Society. It possesses added features as an instructional and assessment strategy to enhance students' cognitive achievement of science concepts.

The literature review on the moderating effect of gender is not conclusive as gender studies reveal different findings. Subject specialization, on the other hand, is under researched in literature. Hence, the need to investigate the effects of these moderating variables.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1.0 Research Design

The study adopted a pretest-post test control group quasi-experimental research design by Campbell and Stanley (1963). The design is chosen because it provides opportunity for studying the effects of treatment on students' knowledge, understanding, and application of selected biology concepts, effects of treatment on students' gender subject specialization and also, the design provides opportunity for studying any possible interaction of treatment on subject specialization and gender on senior secondary school students' knowledge, understanding and application of selected biology concepts.

This study also employs 2 x 2 x 2 factorial matrix to enable the researcher investigate the effect of the independent variable and the moderating variables at the same time. This matrix is presented in Table 3.1

Table 3.1: 2 x 2 x 2 Factorial Matrix of the Study

	Treatment	Gender	Subject specialization	
			Science	Non-science
1.	Mercedes Model with Embedded Assessment Strategy (treatment)	1. Male		
		2. Female		
2.	Conventional Strategy (Control)	1. Male		
		2. Female		

3.2.0 Variables of the Study

The variables in this study include the independent variable which is an instructional strategy at two levels; namely Mercedes Model with Embedded Assessment Strategy in biology and Conventional Strategy in biology, the moderating variables which consist of subject specialization (Science/Non Science) and gender (male and female) while the dependent variables include students' learning outcomes in knowledge, understanding and application of selected Biology concepts.

3.3.0 Population of the Study

The population of this study comprises all Senior Secondary Class II biology students in the six Education Districts of Lagos State.

Sample and Sampling Technique

From six Education Districts (EDs) in Lagos State, two were purposively selected based on the criterion that the two EDs were far away from each other to avoid the problem of contamination. Three senior secondary schools were randomly selected from each Ed based on the availability of at least two graduate biology teachers, fairly well equipped biology laboratories, evidence of having presented students for the Senior Secondary Certificate Examination (SSCE) for at least five years, being a public co-educational secondary school and willingness on the part of the teachers to participate in the study.

A total of six schools in the two selected EDs were involved in the study. Two intact classes (one science and another non science) were randomly selected from each of the six schools making a total of 12 intact classes in all.

Twelve biology teachers were involved in the study. The two EDs were randomly assigned to treatment such that one was the experimental group and the other control group. Students in the Senior Secondary class II (SSII) were used in the study. The choice of SSII students was considered appropriate because these students have been exposed to some basic biological concepts and skills, which had formed an adequate background in biology for the study. Besides, these students have enough time for the experiment (teaching) since they were not preparing for any external examination. The total number of students involved in the study is 666.

3.4.0 Choice of Course Content

The choice of course content on Osmosis and Diffusion as topics for this study was informed by the reports released from WAEC Chief Examiners' Reports (2000, 2003, 2005, 2006) on the poor performance of students in cell and environment/transport in animal and plant aspects of biology. Similarly, an examination of the biology SSCE syllabus and scheme of work showed that the students were just about to start the lesson on cell and its environment.

3.5.0 Research Instruments

The study used five instruments which were adopted and modified by the researcher in the course of this study. They are:

1. Mercedes Model with the Embedded Assessment Strategy in Diffusion (MEASID) and Teacher's instructional guide for Mercedes Model with the Embedded Assessment Strategy in Diffusion (Tig. MEASID)
2. Mercedes Model with the Embedded Assessment Strategy in Osmosis (MEASIO) and Teacher's instructional guide for Mercedes Model with the Embedded Assessment Strategy in Osmosis (Tig. MEASIO)
3. Conventional Lesson Plan on Diffusion (COLPOD) and Teacher's instructional guide for conventional lesson on diffusion.

4. Conventional Lesson Plan on Osmosis (COLPO) and Teacher's instructional guide for conventional lesson on osmosis.

5. Test on Students' Learning Outcomes in Osmosis and Diffusion (TESLOOD).

3.5.1 Mercedes Model with Embedded Assessment Strategy in Diffusion (MEASID

This instrument is a treatment or instructional package developed by the researcher to teach students for improved knowledge, understanding and application of diffusion. It was based on the principles of the Mercedes Model and the Embedded Assessment Strategy of Gallagher (2000). It has three components comprising

* Building knowledge base
* Generating understanding
* Finding application

Each component consists of five embedded questions on five teaching/assessment strategies selected from the thirteen strategies identified by Gallagher. These five questions are to be answered as instruction proceeds.

These five teaching/assessment strategies are:

S_1 - Mind stretcher

S_2 - Models, pictures and diagram

S_3 - Preposition generation

S_4 - Laboratory demonstration

S_5 - Laboratory experiment/record observation

3.5.2 Mercedes Model with Embedded Assessment Strategy in Osmosis (MEASIO)

This instructional package was developed by the researcher to teach and engender students' knowledge, understanding and application of osmosis. It was based on the principle of the Mercedes Model and the Embedded Assessment Strategy of Gallagher (2000). It has three components comprising of:

* Building knowledge base
* Generating understanding
* Finding application

Each component consists of five embedded questions (to be answered as instruction proceeds on five teaching assessment strategies selected from the thirteen strategies identified by Gallagher). The selection of the five teaching/assessment strategies was based on the relevance of the strategies to the concept of osmosis.

Each component of the Mercedes Model with the Embedded Assessment strategies was carefully included into the school biology timetable totaling six contact periods within a week. Each contact period was allotted two periods of 80 minutes.

3.5.3 Validation of MEASID and MEASIO

Copies of MEASID and MEASIO were produced and given to three experts in curriculum development, test measurement and science education to criticize, advice and correct area of ambiguity and suggest area to be improved upon. This is to certify that these instruments are suitable in term of language, clarity, breadth and class. The face validated instrument was administered on Senior Secondary Students II (SSII) of a school that did not participate in the main study. Results obtained were used to established the reliability and internal consistency of the items. The Cronbach alpha value of 0.84 was obtained for the 43 items some of which have negative item total correlations. 13 of such items were removed leaving a total of 30 items with Cronbach coefficient of 0.889. Based on these results, new drafts were made and tried out on a pilot programme. The findings and observations on the pilot programme enhance the final adjustment of the instruments

3.5.4 Teachers' Instructional Guide for Mercedes Model with Embedded Assessment Strategy in Diffusion (TIG. MEASID)

The Teacher's Instructional Guide for Mercedes Model with Embedded Assessment strategy (TIG. MEASID) is an instructional guide for the treatment group (experimental) on diffusion. This includes the basic procedural steps in a typical lesson plan; which are: Topic, Duration, instructional objectives, previous knowledge, reference and procedural steps. However, the procedural steps involve the three components of the Mercedes Model which includes:

* Building knowledge base
* Generating understanding
* Finding application

Each section embraces five embedded questions on five assessment strategies selected from the thirteen strategies identified by Gallagher. Unlike MEASID and MEASIO, TIG.MEASID contains embedded questions and answers on diffusion. Each component of the Mercedes Model with the Embedded Assessment strategies were carefully included into the school biology timetable totaling six contact periods within a week.

Steps involved in the Mercedes Model with the Embedded Assessment Strategy in Diffusion include:

* Building Knowledge Base

The teacher:-

(i) introduces the lesson by relating a real life story of 'country's map and borders to a cell membrane.

(ii) uses embedded assessment strategy as check-point - preposition strategy (S_3)

(iii) explains in logical sequence the concept of diffusion

(iv) uses embedded assessment strategy laboratory experiment/record observation (S_5)

(v) explains the concept of equilibrium, and factors controlling diffusion

(vi) uses embedded assessment strategy - mind stretcher (S_1) and Model Pictures and Diagrams (S_2)

(vii) wraps up the lesson and uses Embedded Assessment Strategy Laboratory Demonstration - (S_4)

* Generating understanding

The students with the teacher's assistance

(i) display the process of diffusion

(ii) carry out demonstration: Experiment to demonstrate Diffusion in gases, solids and liquids with teacher's assistance.

(iii) the students answer embedded assessment questions; laboratory demonstration – S_4 mind stretcher (S_1), Laboratory Experiment/Record Observation (S_5) Models/Pictures/Diagrams (S_2), Preposition generation (S_3)

Teacher wraps up the lesson.

* Finding Application

Both teacher and students:

(i) discuss the importance of diffusion to flowering plants, animals, diffusion in nature on non-living conditions, while the teacher emphasizes salient points.

(ii) discuss further size of molecules crossing cell membrane after which students analyze data.

The students:

(iii) use embedded assessment strategies (S_1), (S_2), (S_3) (S_4) (S_5) and teacher wraps up the lesson and uses embedded assessment strategy (S_4)

3.5.5 Teachers' Instructional Guide for Mercedes Model with Embedded Assessment on Osmosis (TIG. MEASIO)

The Teachers' Instructional Guide for Mercedes Model with Embedded Assessment on Osmosis is an instructional guide for the treatment (experimental) on osmosis. This includes the basic procedural steps in a typical lesson plan; which are: topic, duration, instructional objectives, previous knowledge, reference and procedural steps. However, the procedural steps involve the three sectional components of the Mercedes Model which includes;

* Building knowledge base
* Generating understanding
* Finding application

Each component contains five embedded questions on five teaching and assessment strategies. Each embedded question contains answers. All the three components were allotted six periods within a week.

Steps involved in the Mercedes Model with Embedded Assessment Strategy in Osmosis include:

* Building Knowledge Base

The teacher:-

(i) explains substances crossing biological membrane using a picture of the cell membrane and introduce the concept of osmosis.

(ii) Uses the embedded assessment strategy – Model/Picture/Diagram (S_2).

(iii) explains further how osmosis works, condition necessary for osmosis, living cells as osmometer, and differences between osmosis

(iv) engages students by using embedded assessment strategies (S_3) (S_1) (S_4) and diffusion.

(v) divides class into groups to carry out experiment on the effects of hypertonic and hypotonic solutions.

(vi) uses embedded assessment strategy (S_5)

(vii) wraps up the lesson.

* Generating Understanding

The students with the teacher's assistance:-

(i) put up a demonstration to show osmosis

(ii) answer embedded assessment strategies (S_4)

The teacher:-

(i) uses diagram to explain the effects of osmosis in cells and students answer embedded assessment strategies (S_2) (S_3)

(ii) discusses osmotic pressure and students answer embedded assessment strategy (S_1)

(iii) wraps up the lesson by using embedded assessment strategy (S_5)

* Finding Application

The teacher and students:-

(i) review lesson by using a real-life circumstance of a home owner and a lawn contractor and students answer embedded assessment strategy (S_1)

(ii) discuss plasmolysis, and the process of plasmolysis in plants

(iii) carry out a demonstration on plasmolysis using spirogyra and students answer embedded assessment strategy (S_4) (S_2)

(iv) carry out an experiment to demonstrate heamolysis in Red Blood cell

(v) compare plasmolysis and heamolysis and students answer embedded assessment strategy (S_3) (S_5) to wrap up the lesson.

3.5.6 Validation of TIG-MEASID and TIG. MEASIO

Tig. MEASID and Tig. MEASIO were given to seven experienced secondary school biology teachers to determine procedural effect of the instructional guides and its suitability for the samples. The corrected versions were given to two qualified secondary school teachers to try on selected subjects that were grouped into two. Each teacher worked on a group each. Modifications were made on Tig MEASID and Tig MEASIO to get final drafts.

3.5.7 Conventional Lesson Plans on Diffusion and Osmosis COLPOD and COLPO

These instrument were developed based on the steps involved in the conventional lecture method of instruction which are: topic, objectives of each lesson stated in behavioural or instructional manner, previous knowledge, materials, references, introduction, procedures/presentation, evaluation and assignment. These steps were followed in the preparation of the lesson plans. In all, there were twelve contact periods on the concept sof diffusion and osmosis. Each contact period was allotted 40 minutes on the school's time-table totaling 80 minutes per day. The instructional procedure involved introduction of concepts, explanation of key concepts, description, discussion and questions. Brief summary and assignment were given to the students. The instructional periods lasted two weeks.

3.5.8 Validation of COLPOD and COLPO

These instruments were given to three experienced teachers that have taught Biology for well over 10 years at the senior secondary school levels for advice on the suitability of the instrument. Their suggestions and corrections helped at the final adjustments made on these instruments.

3.5.9 Test on Students' Learning Outcomes in Diffusion and Osmosis (TESLOOD)

This test was designed to measure students' learning outcomes in diffusion and osmosis based on the three components of the Mercedes Models which are knowledge, understanding and application. Each component consists of five embedded questions on five assessment strategies out of the thirteen identified by Gallagher. In all, there are thirty questions. The table of specification for the construction of TESLOOD is presented in the Table 3.2

Table 3.2: Table of Specification for TESLOOD

Strategies							
Topic	Components	S1	S2	S3	S4	S5	Total
Diffusion	Knowledge Understanding Application	1(3) 1(2) 1(4)	1(4) 1(2) 1(1)	1(1) 1(5) 1(2)	1(5) 1(1) 1(5)	1(2) 1(3) 1(3)	5 5 5
Osmosis	Knowledge Understanding Application	1(3) 1(4) 1(1a,b,c)	1(1a,b,c) 1(2) 1(3)	1(2) 1(3) 1(4)	1(4) 1(1a,b,c) 1(2)	1(5) 1(5) 1(5a,b,c)	5 5 5
Total		6	6	6	6	6	30

Figures in parentheses are item numbers

TESLOOD is the pre-test instrument for both experimental and control groups as well as the post test instrument for the control and experimental groups.

3.5.9i Validation of TESLOOD

First, copies of TESLOOD were given out to experts in Biology Education and Biology teachers in senior secondary schools for scrutiny both in terms of content and coverage. Also, language and construct validity were ensured by sampling language experts and test construction experts. The draft test was administered on twenty-five senior secondary class II students for reliability.

After two weeks, the test was administered to the same set of students. The responses obtained were used to ascertain the test - re-test reliability coefficient which was 0.74 with an average item difficulty of 0.47.

3.6.0 Pilot Study

A pilot study was carried out before the main study. This was purposively done in order to identify some potential logistical and methodological problems that might ensue thereby threatening the internal and external validity of the study. Similarly, the pilot study was undertaken in order to validate the research instruments intended for use in the main study. For the purpose of the pilot study, two SSII biology teachers were trained for two weeks to use the Mercedes model and the embedded assessment strategies. The instruments were administered to 50 students in senior secondary school class II in Lagos State. The result of the pilot study enhanced the modification of the instrument and some psychometric properties of the same were also determined. The method of administration was also adjusted.

3.7.0 Procedure for Data Collection

The procedure for data collection is divided into three major stages

1. Preliminary activities
2. Treatment
3. Post treatment

3.7.1 Preliminary Activities

Letters of introduction were collected by the researcher from the Head of Department of Science and Technology Education, University of Lagos to the Principals of the different schools selected for the research. Meetings with biology teachers in the six different schools were scheduled after which training the teachers for the research began. Six teachers in each group i.e. experimental and control groups were trained. Stratified random sampling was used to select teachers based on

(a) Qualification, which was a minimum of B.Sc. (Ed) or B. Ed. Biology and

(b) Minimum of 5 years cognate experience.

The stratified randomly selected teachers were randomly grouped into two. Training in the experimental group involves; first, the six teachers were introduced to the content of osmosis and diffusion. Next, the teachers were exposed to the Mercedes Model and the Embedded Assessment Strategy. Demonstration of the Mercedes Model and the Embedded Assessment strategy was carried out by the researcher during the first week to enhance teachers' understanding. Then, teachers took turns to use the Mercedes Model and the Embedded Assessment Strategy in micro teaching. Finally, corrections were made and a re-teach done immediately. All of these activities were done for two weeks. Also, teachers in the conventional group had teaching demonstrations on diffusion and osmosis using the modified lecture method as it is commonly used in classroom.. The teachers also were trained to score the instruments.

3.7.2 Pre-Test

The TESLOOD was administered to all the students in both the experimental and control groups during the first week.

3.7.3 Treatment Administration

Treatment Administration lasted for two weeks. The experimental group was exposed to the Mercedes Model with the Embedded Assessment Strategy while the control group was exposed to the conventional strategy simultaneously.

3.7.4 Treatment Group (Experimental Group)

The treatment was divided into 3 stages for each of the two concepts (diffusion and Osmosis). In the first stage, the students were exposed to building knowledge component of the Mercedes Model. The next stage was generating understanding and finally was finding application.

In all six periods in a week was used to teach diffusion or osmosis students answered five questions at each stage totaling 15 questions in all for diffusion or osmosis.

3.7.5 Control Groups: Conventional Group

This group was taught using the conventional method as contained in the instructional guide for diffusions and osmosis. Students were assessed at the end of instruction.

3.7.6 Post-Test

The TESLOOD was administered to the control group at the end of each instruction on diffusion and osmosis. In all, the study lasted five weeks.

3.8.0 Scoring of Instrument

The three instruments (MEASID, MEASIO and TESLOOD) were scored manually by the researcher as follows: for each item, each correct response on either MEASID, MEASIO or TESLOOD attracted two points, while wrong response attracted zero. The response of each student in each was summed up separately. For each of these, the obtainable scores range from zero (0) to thirty (30) making a total of 60 points for both MEASID and MEASIO and another 60 points for TESLOOD. For each of the scores obtained by the students, the percentage was computed and used for data analysis.

3.9.0 Procedure for Data Analysis

Data collected were analyzed using both descriptive and inferential statistics. The descriptive statistics include frequency counts and means while analysis of covariance (ANCOVA) as an inferential statistics was also used. ANCOVA was utilized to control for initial differences between groups in the study i.e. pretest before a comparison of the within groups variance and between groups variance was made. The Multiple Classification Analysis was used to present the descriptive table of the groups' performance in the study.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF RESULT

INTRODUCTION

The findings of this study are as presented in this chapter. Analysis of data collected was used to test the seven null hypotheses earlier postulated for the study. Tables and figures have been used in the presentation as deemed necessary. Illumination of salient aspects of the tables and figures has been done with brief description of the findings.

4.1.0 Presentation of Results

The descriptive tables for the pre and post-test mean scores of students in knowledge, understanding and application based on the independent and moderating variables are first presented.

Table 4.1: Pre and Post Test Mean Scores of Students Knowledge in the Various Groups

Variable	Category	N	Pre-Knowledge	Post-Knowledge
Treatment	Mercedes Model	399	14.71	59.95
	Control	267	12.72	26.19
Subject Specialization	Science	347	17.28	51.51
	Non-science	319	15.25	40.88
Gender	Male	405	15.23	51.16
	Female	261	13.91	46.42

Table 4.1 shows that students exposed to the Mercedes Model obtained a mean pre-test score of 14.71 while they obtained 59.95 at the post-test. For the control group, the mean score increased from 12.72 to 26.19.

On subject specialization, science students had 17.28 and 51.51 at pre-test and post-test respectively while that of non-science students increased from 15.25 to 40.88. Also, the male students obtained 15.23 at pre-test while 51.16 is the post-test mean score in their knowledge of osmosis and diffusion. This changed from 13.91 to 46.42 at pre-test and post-test respectively in relation to the female students. This information is represented in Figure 4.1 below.

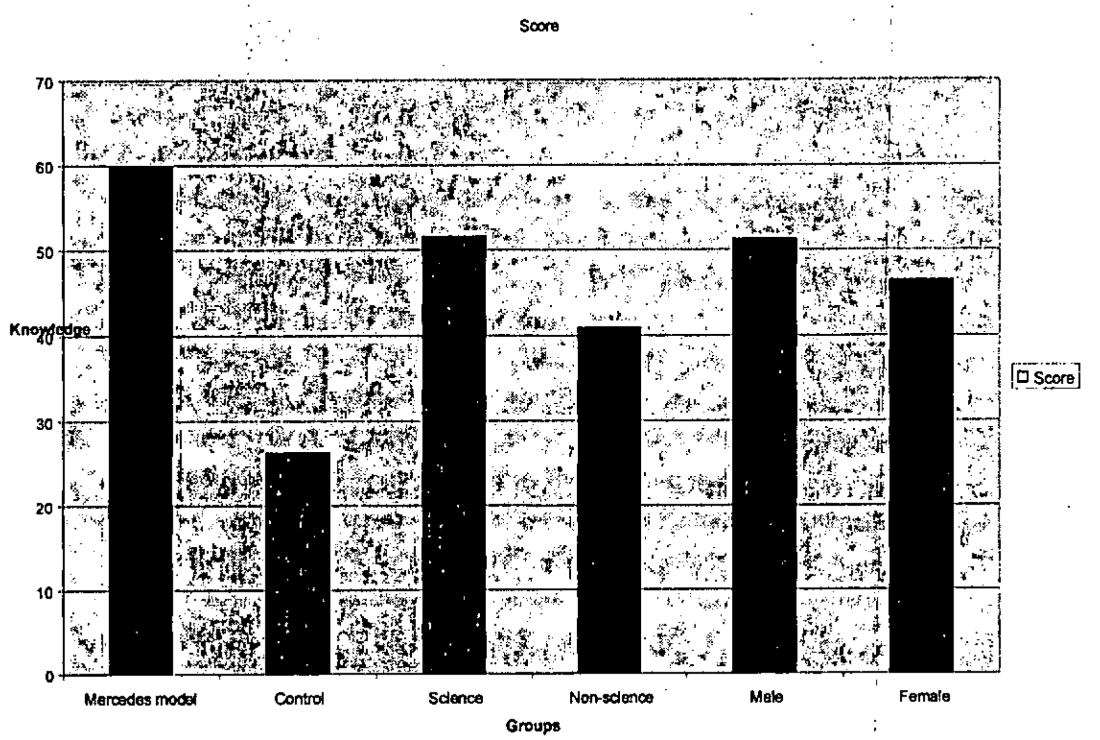


Fig. 4.1: Bar graph showing the Post Test Knowledge Scores of Students in Osmosis and Diffusion

Table 4.2: Pre and Post Test Mean Scores of Students Understanding in the Different Groups

Variable	Category	N	Pre-Understanding	Post-Understanding
Treatment	Mercedes Model	399	4.83	55.01
	Control	267	3.34	11.16
Subject Specialization	Science	347	5.89	43.69
	Non-science	319	4.44	30.63
Gender	Male	405	4.30	41.41
	Female	261	4.14	31.26

Table 4.2 shows that students in the Mercedes Model with Embedded Assessment strategy group obtained 4.83 in pre-test for understanding and 55.01 in the post-test. For the control group, the mean score at pre-test is 3.34 while it is 11.16 at the post-test. Further, Table 4.2 reveals that science students obtained 5.89 and 43.69 at the pre-test and post-test respectively compared to 4.44 and 30.63 obtained by the non-science students at pre-test and post-test levels. On Gender, males had pre-test score of 4.30 and post-test score of 41.41 while their female counterparts had 4.14 and 31.26 at pre-test and post-test respectively.

These information were used to prepare the bar graph i.e Figure 4.2 which better illuminates the descriptive statistics presented above.

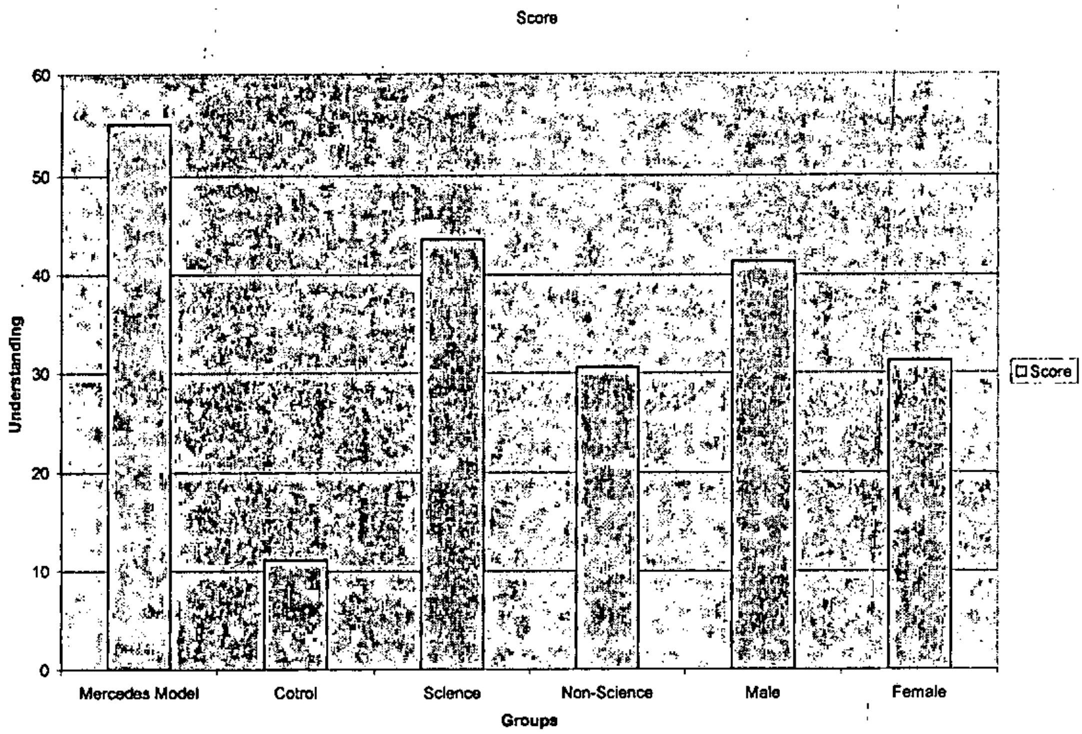


Fig. 4.2: Bar Graph showing the Post Test Understanding Scores of Students in Osmosis and Diffusion

Table 4.3: Students Mean Scores in Application at Pre-Test and Post-Test

Variable	Category	N	Pre-Knowledge	Post-Knowledge
Treatment	Mercedes Model	399	10.10	60.25
	Control	267	9.22	24.14
Subject Specialization	Science	347	13.02	48.57
	Non-science	319	10.28	42.73
Gender	Male	405	10.34	48.44
	Female	261	8.83	41.63

From Table 4.3, the mean application score of students in the Mercedes Model at pre-test is 10.10 while it is 60.25 at post-test. For the control group, this is 9.22 at pre-test and 24.14 at post-test. Further, students in the science class obtained 13.02 and 48.57 at pre-test and post-test respectively while those in the non-science class obtained 10.28 and 42.73 in the same order. For the male students, the mean scores changed from 10.34 (pre-test) to48.44 (post-test) while the females had 8.83 and 41.63 at pre-test and post-test respectively. These information were used to prepare the figure 4.3 i.e bar graph which illuminates the descriptive statistics presented better.

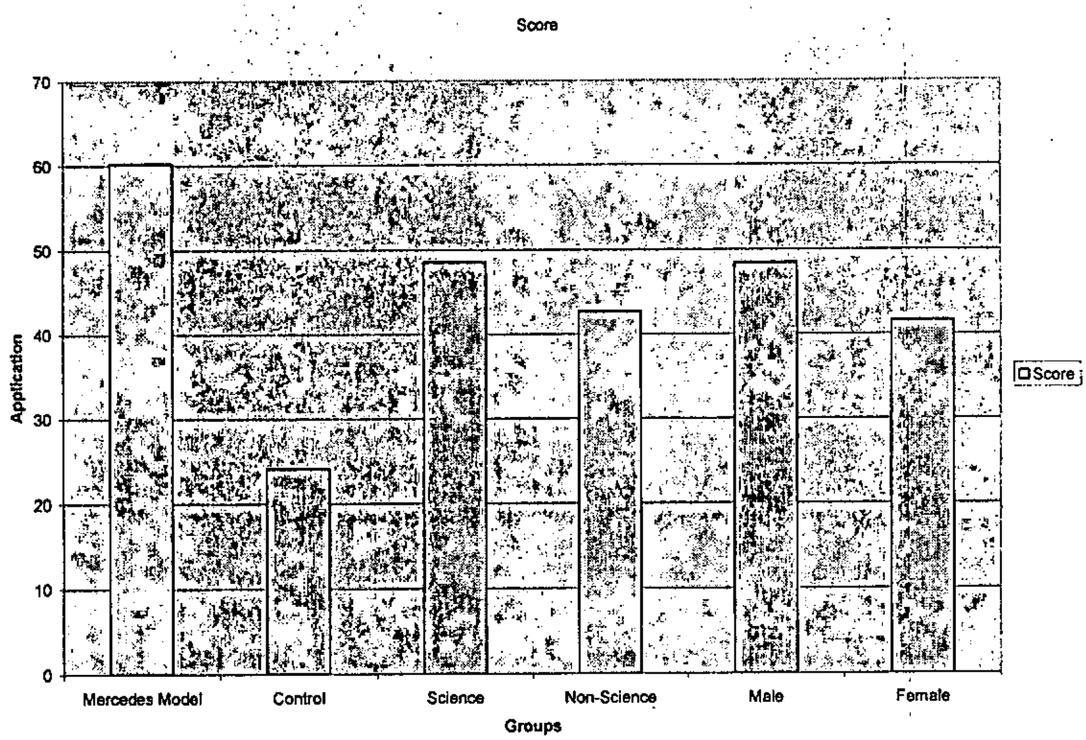


Fig. 4.3: Bar graph Showing the Post Test Application Scores of Students in Osmosis and Diffusion

A cursory look at figures 4.1, 4.2 and 4.3 reveals that the Mercedes Model group of students performed better in knowledge, understanding and application than their control group counterparts. This difference is so wide compared with the difference between science and non-science students and between male and female students where the differences are not wide but then science was better than non-science and males better than females.

4.2.0: Test of Hypotheses

Ho1a: There is no significant difference in students' knowledge of selected biology concepts after exposure to the Mercedes Model with embedded assessment strategy and in the control group.

Table 4.4 presents the summary of ANCOVA results on students' knowledge.

Table 4.4: ANCOVA of Knowledge Scores of Students by Treatment, Subject Specialization and Gender

Source of Variance		Hierarchical Method				
		Sum of Square	**df**	**Mean Square**	**F**	**Sig.**
Covariates	PREKNOW	49335.665	1	49335.665	194.029	.000
Main Effects	(Combined)	195032.7	3	65010.885	255.677	.000
	TREATMT	168927.4	1	168927.4	664.362	.000 *
	SUBJSPEC	24222.167	1	24222.167	95.262	.000 *
	Gender	1883.129	1	1883.129	7.406	.007 *
2 Way Interactions	(Combined)	14914.867	3	4971.622	19.553	.000
	TREATMT x SUBJSPEC	13115.633	1	13115.633	51.582	.000
	TREATMT x Gender	75.689	1	75.689	.298	.586
	SUBJSPEC x Gender	1979.420	1	1979.420	7.785	.005 *
3 Way Interactions	TREATMT x SUBJSPEC x Gender	575.204	1	575.204	2.262	.133
Model		259858.4	8	32482.299	127.747	.000
Residual		167055.4	657	254.270		
Total		426913.8	665	641.976		

* Significant at $p < .05$

Table 4.4 shows that there is a significant effect of treatment on students' Knowledge of selected biology concepts (F (1,657) = 664.362; p<.05). Hence, hypotheses 1a is rejected. This means that there is a significant difference in students' knowledge of selected biology concepts after exposure to the Mercedes Model with embedded assessment strategy than those in the control group.

The MCA Table 4.5 further presents the respective levels of performance for the experimental and control groups.

Table 4.5: Multiple Classification Analysis of Post-Test Knowledge According to Treatment, Subject Specialization and Gender

			Predicted Mean		Deviation			
Treatment + Category		**N**	**Un Adjusted**	**Adjusted For Factors and Covariates**	**Un Adjusted**	**Adjusted For Factors and Covariates**	**Eta**	**Beta**
TREATMT	Mercmodel	399	59.9499	60.1605	13.5340	13.7446	.653	.664
	Control	267	36.1910	35.8763	-20.2249	-20.5396		
SUBJSPEC	Science	347	51.5072	52.2512	5.0913	5.8353		
	Non-Science	319	40.8777	40.0684	-5.5382	-6.3475	.210	.240
GENDER	Male	405	51.1605	47.8098	4.7446	1.3939		
	Female	261	39.0536	44.2529	-7.3623	-2.1630	.233	.069
R = .757								
R Square = .572								

From Table 4.5, students in the Mercedes Model group obtained higher Knowledge mean score ($\bar{x}$ = 60.16) than those in the control group ($\bar{x}$ =35.88). This difference is so wide and has been found to be significant as indicated in Table 4.4.

HO1b: There is no significant difference in students' understanding of selected biology concepts after exposure to the Mercedes Model with embedded assessment strategy and in the control group.

Table 4..6: ANCOVA of Understanding Scores by Treatment, Subject Specialization and Gender

Source of Variance	Sum of Square	df	Mean Square	F	Sig.
Covariates PREUNDER	19600.298	1	19600.298	59.465	.000
Main Effects (Combined)	354036.6	3	118012.2	358.034	.000
TREATMT	295318.7	1	295318.7	895.959	.000 *
SUBJSPEC	58716.300	1	58716.300	178.138	.000 *
Gender	1.578	1	1.578	.005	.945
2 Way Interactions (Combined)	8220.842	3	2740.281	8.314	.000
TREATMT x SUBJSPEC	4240.007	1	4240.007	12.864	.000 *
TREATMT x Gender -	310.930	1	310.930	.943	.332
SUBJSPEC x Gender	5721.158	1	5721.158	17.357	.000 *
3 Way Interactions TREATMT x SUBJSPEC x Gender	3696.681	1	3696.681	11.215	.001 *
Model	385554.4	8	48194.305	146.215	.000
Residual	216555.0	657	329.612		
Total	602109.5	665	905.428		

* Significant at p<.05

From Table 4.6, treatment has a significant effect on students' understanding (F (1,657) = 895.959;p<.05). Therefore, hypotheses 1b is rejected. This implies that there is a significant difference in the students' understanding of selected biology concepts after exposure to the Mercedes Model and the conventional teaching method.

Table 4.7: Multiple Classification Analysis of Post-Test Understanding According to Treatment, Subject, Specialization and Gender

Treatment + Category		N	Predicted Mean		Deviation		Eta	Beta
			Un Adjusted	Adjusted For Factors And Covariates	Un Adjusted	Adjusted For Factors and Covariates		
TREATMT	Mercmodel	399	55.0125	56.1743	17.5801	18.7419		
	Control	267	21.1610	29.4249	-26.2714	-28.0075	.715	.762
SUBJSPEC	Science	347	43.6888	46.8540	6.2563	9.4215		
	Non-Science	319	30.6270	27.1839	-6.8055	-10.2485	.217	.327
GENDER	Male	405	41.4074	37.3921	3.9750	-.4.03E-02		
	Female	261	31.2644	37.4950	-6.1681	6.256E-02	.165	.002
R = .788								
R Square = .621								

The MCA Table 4.7 reveals that the students' exposed to the Mercedes Model obtained a higher understanding score ($\bar{x}$ = 56.17) than those in the control strategy group ($\bar{x}$=29.42).

This difference has been found to be significant on Table 4.6

Ho1c: There is no significant difference in students' application of selected biology concepts after exposure to the Mercedes Model with Embedded Assessment strategy and in the control.

Table 4.8: Summary of ANCOVA of Application Scores by Treatment, Subject Specialization and Gender

Source of Variance	Hierarchical Method				
	Sum of Squares	df	Mean Square	F	Sig.
Covariates PREAPPLI					
Main Effects (Combined)	41125.421	1	41125.421	102.120	.000
TREATMT	212579.7	3	70859.916	175.954	.000*
SUBJSPEC	201227.5	1	201227.5	499.673	.000*
Gender	11194.364	1	11194.364	27.797	.000*
2 Way Interactions (Combined)	157.882	1	157.882	.392	.531
TREATMT x	4612.712	3	1537.571	3.818	.010
SUBJSPEC	3025.357	1	3025.357	7.512	.006*
TREATMT x					
Gender					
SUBJSPEC x	255.521	1	255.521	.634	.426
Gender					.332
3 Way Interactions TREATMT x	379.246	1	379.246	.942	.088
SUBJSPEC x					.000
Gender	1172.795	1	1172.795	2.912	
Model					
Residual					
Total	259490.7				
	264586.1	8	32436.335	80.676	
	524076.8	657	402.719		
		665	788.085		

* Significant at p< .05

Table 4.8 shows that there is a significant effect of treatment on students' application of selected biology concepts (F (1,657) = 499.673;p<.05). On this basis, hypotheses 1c is rejected. This finding implies that there is a significant difference in students' application of selected biology concepts after exposure to the Mercedes Model with embedded assessment strategy and in the control group.

Table 4.9: Multiple Classification Analysis of Post-Test Application Score by Treatment, Subject, Specialization and Gender

Treatment + Category		N	Predicted Mean		Deviation		Eta	Beta
			Un Adjusted	Adjusted For Factors And Covariates	Un Adjusted	Adjusted For Factors and Covariates		
TREATMT	Mercmodel	399	60.2506	60.6452	14.4774	14.8720		
	Control	267	34.1386	33.5489	-21.6347	-22.2244	.631	.648
SUBJSPEC	Science	347	48.5735	49.9610	2.8002	4.1877		
	Non-Science	319	42.7273	41.2180	-3.0460	-4.5553	.104	.156
Gender	Male	405	48.4444	45.3705	2.6712	-.4028		
	Female	261	41.6284	46.3983	-4.1449	.6250	.119	0.18
R = .696								
R Square = .484								

From Table 4.9, students in the experimental group (Mercedes Model with embedded assessment strategy) performed better in application ($\bar{x} = 60.65$) than their counterparts in the control strategy group ($\bar{x} = 33.55$).

Ho2a: There is no significant difference between science and non-science students' knowledge in the experimental and control groups.

From Table 4.4, subject specialization has a significant effect on students' knowledge of the selected biology concepts ($F (1,657) = 95.262; p<.05$). Hence, hypothesis 2a is rejected.

This means that science and non-science students' knowledge of the selected concepts differ significantly after the treatment administration.

Table 4.5 further revealed that the mean score obtained by the science students is higher ($\bar{x}$ = 52.25) than that of the non-science students ($\bar{x}$ = 40.07) in knowledge in the experimental and control groups.

Ho2b: There is no significant difference between science and non-science students understanding in the experimental and control groups.

From Table 4.6, it has been shown that subject specialization has a significant effect on students' understanding of osmosis and diffusion ($F.(1,657) = 178.138; p<.05$). On the basis of this finding, hypothesis 2b is rejected. Hence, students in the science and non-science classes differ- significantly in their post-test understanding of the selected biology concepts.

Table 4.7 also showed that the science students had more understanding ($\bar{x}$ = 46.85) than their non-science counterparts ($\bar{x}$ = 27.18).

Ho2c: There is no significant difference between science and non-science students' application in the experimental and control groups.

From Table 4.8, the main effect of subject specialization on students' application of the selected biology concepts is significant ($F (1,657) = 27.797; p<.05$). Hypotheses 2c is therefore rejected. To this end, the difference between science and non-science students' application of the selected concepts is significant.

Table 4.9 also showed that it is the science group of students that had the better application score ($\bar{x}$ = 49.96) than the non-science group ($\bar{x}$ = 41.22).

Ho3a: There is no significant difference in the male and female students' knowledge in the experimental and control groups.

Table 4.4 showed that gender has a significant effect on students' knowledge in the experimental and control groups ($F(1,657) = 7.406; p<.05$). This led to the hypotheses 3a being rejected. This means that the knowledge acquired by male students is significantly different from the level acquired by the female students.

Table 4.5 showed that the male students' knowledge rates higher ($\bar{x}= 47.81$) than that of the female students ($\bar{x} = 44.25$).

Ho3b: There is no significant difference in the male and female students' understanding in the experimental and control groups.

From Table 4.6 it is obtained that gender has no significant effect on students' understanding of the selected concepts ($F(1,657) = .005; p>.05$). Hence hypothesis 3b is not rejected. This implies that the difference in the male and female students' understanding is not significant.

Table 4.7 showed that the female students obtained a higher mean score in understanding ($\bar{x} = 37.50$) than the male students ($\bar{x} = 37.39$). However, this difference is not significant.

Ho3c: There is no significant difference in the male and female students' application in the treatment and control groups.

Table 4.8 showed no significant effect of gender on students' application of the selected concepts ($F(1,657) = 0.392; p>.05$). Hypothesis 3c is therefore not rejected. This implies that the male and female students' levels of application after exposure to the experimental and control do not differ significantly.

Further, Table 4.9 showed that the female students' performed better in application ($\bar{x}$ = 45.37 than the male ($\bar{x}$= 46.40) but this difference is not significant.

Ho4a: There is no significant difference in the science and non-science students' knowledge of selected Biology concepts in each of the experimental and control groups.

From Table 4.4 the interaction effect of treatment and subject specialization on students' knowledge is significant (F (1,657) = 51.582;p<.05). Hypothesis 4a is therefore rejected. The nature of this interaction is explained using Figure 4.4.

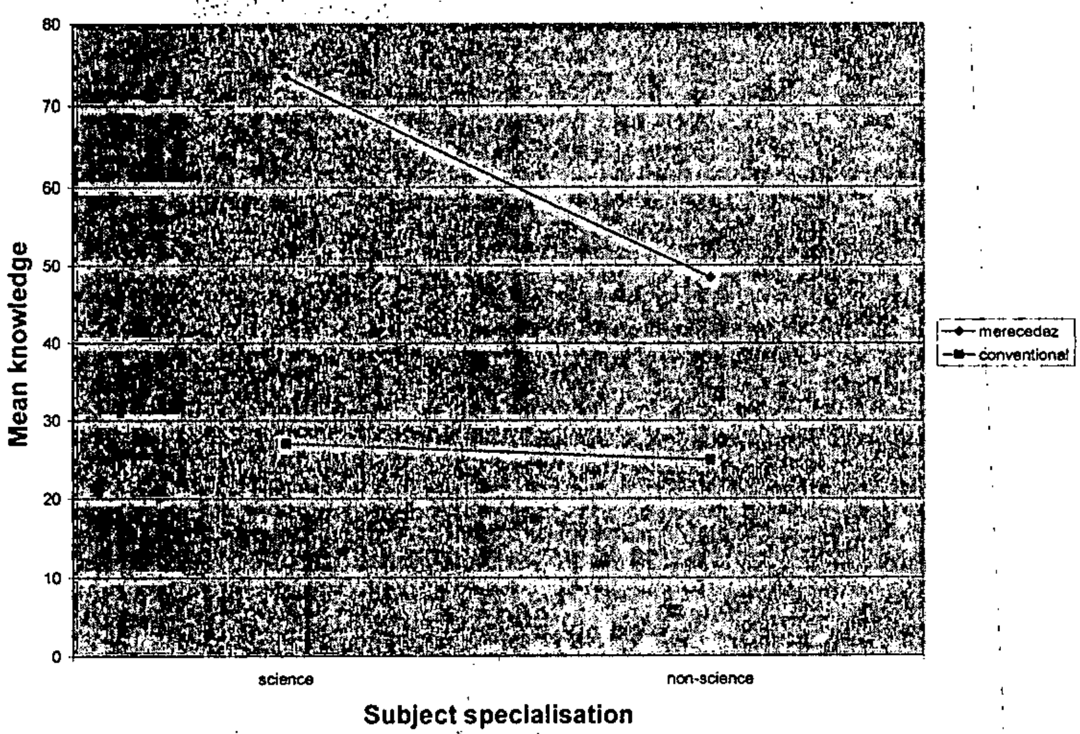


Figure 4.4: Interaction Effect of Treatment and Subject Specialization on Knowledge

Figure 4.4 shows that among the science students, those in the Mercedes Model performed better ($\bar{x}$ = 73.49) in knowledge than their counterparts in the control group ($\bar{x}$ = 26.96). Also, in the non-science class, the Mercedes Model group ($\bar{x} = 48.47$) performed better than the control group ($x = 24.95$). This interaction is therefore, ordinal as the trend is similar both among the science and non-science groups of students.

Ho4b: There is no significant difference in the science and non-science students' understanding of selected biology concepts in each of the experimental and control groups.

Table 4.6 showed that the 2-way interaction effect of treatment and subject specialization on students' understanding of selected Biology concepts is significant ($F(1,657) = 12.864; p<.05$). Hence, hypothesis 4b is rejected. This interaction is illuminated using figure 4.5.

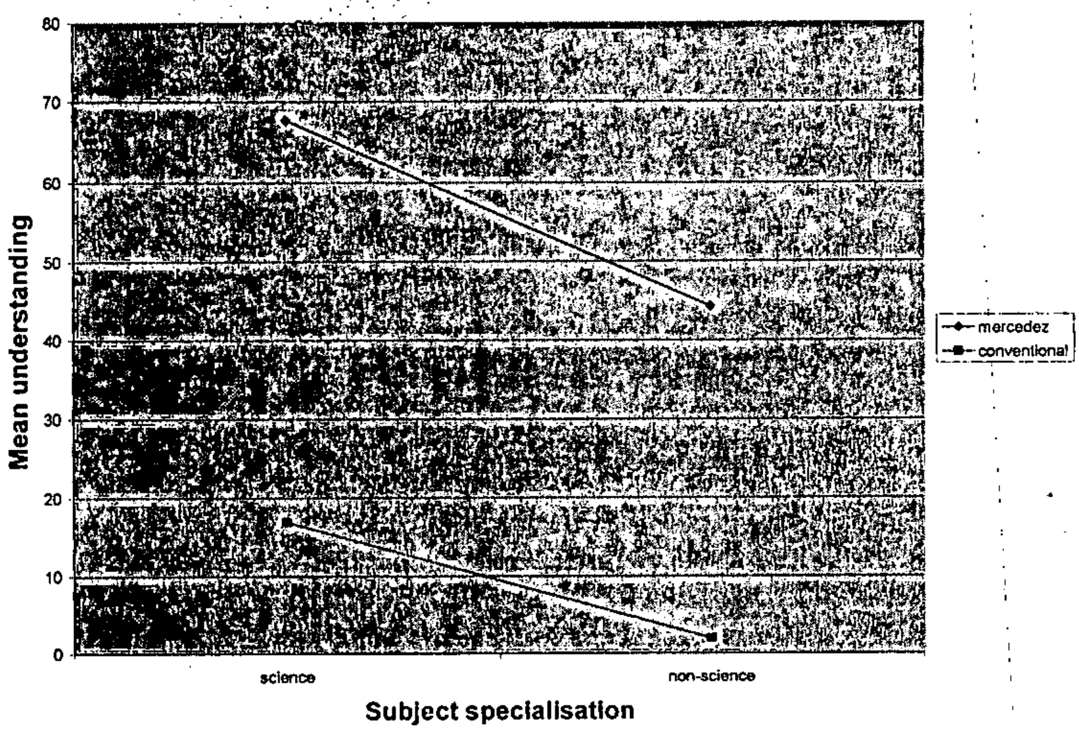


Figure 4.5: Interaction Effect of Treatment and Subject Specialization on Understanding

Figure 4.5 shows that the Mercedes Model treatment was more effective for both sciences ($\bar{x}= 67.71$) and non-science ($\bar{x} = 44.26$) than the control strategy was for science ($\bar{x} = 16.89$) and non-science ($\bar{x} = 2.04$). This is also an ordinal interaction.

Ho4c: There is no significant difference in the science and non-science students' application of selected biology concepts in each of the experimental and control groups.

From Table 4.8, there is a significant interaction effect of treatment and subject specialization on students' application of the biology concepts (F (1,657 = 7.512;p<.05). Therefore, hypotheses 4c is rejected.

This significant interaction effect is further explained in figure 4.6.

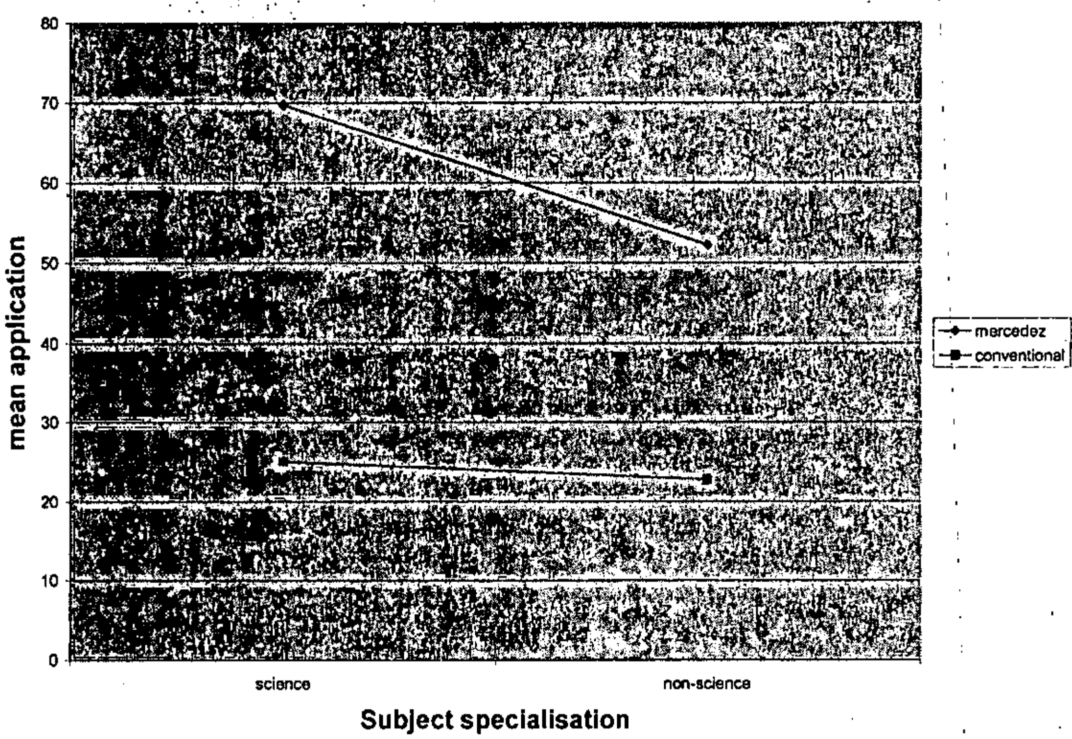


Figure 4.6: Interaction of Treatment and Subject Specialization on Application

Figure 4.6 shows that among the science students, the Mercedes Model was more effective on application ($\bar{x}$ = 69.73) than the conventional strategy ($\bar{x}$ = 24.97). Also, for the non-science students, the Mercedes Model proved better ($\bar{x}$ = 52.22) than the conventional ($\bar{x}$ = 22.82). This is an ordinal interaction.

Ho5a: There is no significant difference between the male and female students' knowledge of selected biology concepts in each of the experimental and control groups.

Table 4.4 showed that there is no significant interaction effect of treatment and gender on students' knowledge ($F(1,657) = 0.298; p>.05$). Hence, hypothesis 5a is not rejected.

Ho5b: There is no significant difference between the male and female students' understanding of selected biology concepts in each of the experimental and control groups.

Table 4.6 showed that treatment and gender have no significant interaction effect on students' understanding of the biology concepts ($F(1,657) = 0.943; p>.05$). Hypothesis 5b is therefore not rejected.

Ho5c: There is no significant difference between the male and female students' application of selected biology concepts in each of the experimental and control groups.

Table 4.8 revealed that there is no significant interaction effect of treatment and gender on students' application of selected biology concepts ($F(1,657) = 0.634; p>.05$). Hence, hypothesis 5c is not rejected.

Ho6a: There is no significant difference between the science and non-science students' knowledge of selected biology concepts among those who are males and females after exposure to the experimental and control groups.

Table 4.6 showed that there is a significant interaction effect of subject specialization and gender on students' knowledge ($F(1,657) = 7.785; p<.05$). Hence, hypothesis 6a is rejected.

Figure 4.7 provides explanation of the significant interaction effect.

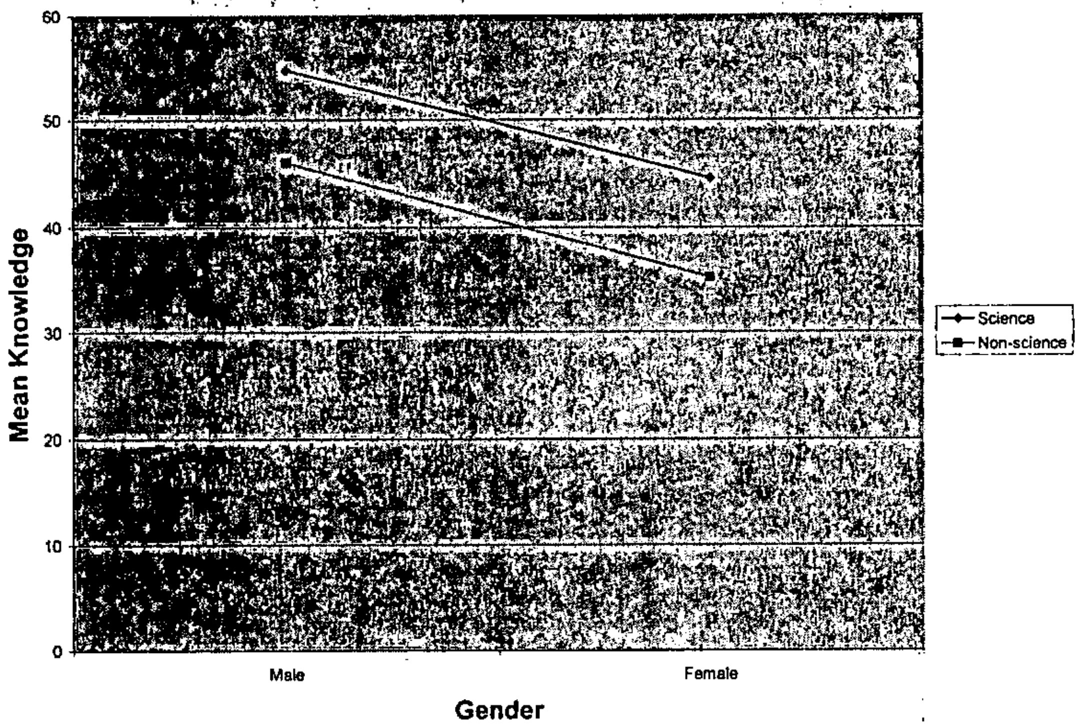


Figure 4.7: Interaction Effect of Subject Specialization and Gender on Knowledge

Figure 4.7 shows that among the male students, the science students performed better ($\bar{x} = 54.75$) than the non-science students ($\bar{x} = 46.05$). Also, this trend is the same for the female students among whom the science students performed better ($\bar{x} = 44.59$) than the non-science students ($\bar{x} = 39.05$). This is also ordinal.

Ho6b: There is no significant difference between the science and non-science students' understanding of selected biology concepts among those who are males and females after exposure to the experimental and control groups.

From Table 4.6, the interaction effect of subject specialization and gender is significant on students' understanding (F (1,657) = 17.357;p<.05). On this basis, hypothesis 6b is rejected. Figure 4.8 is presented to illuminate this finding.

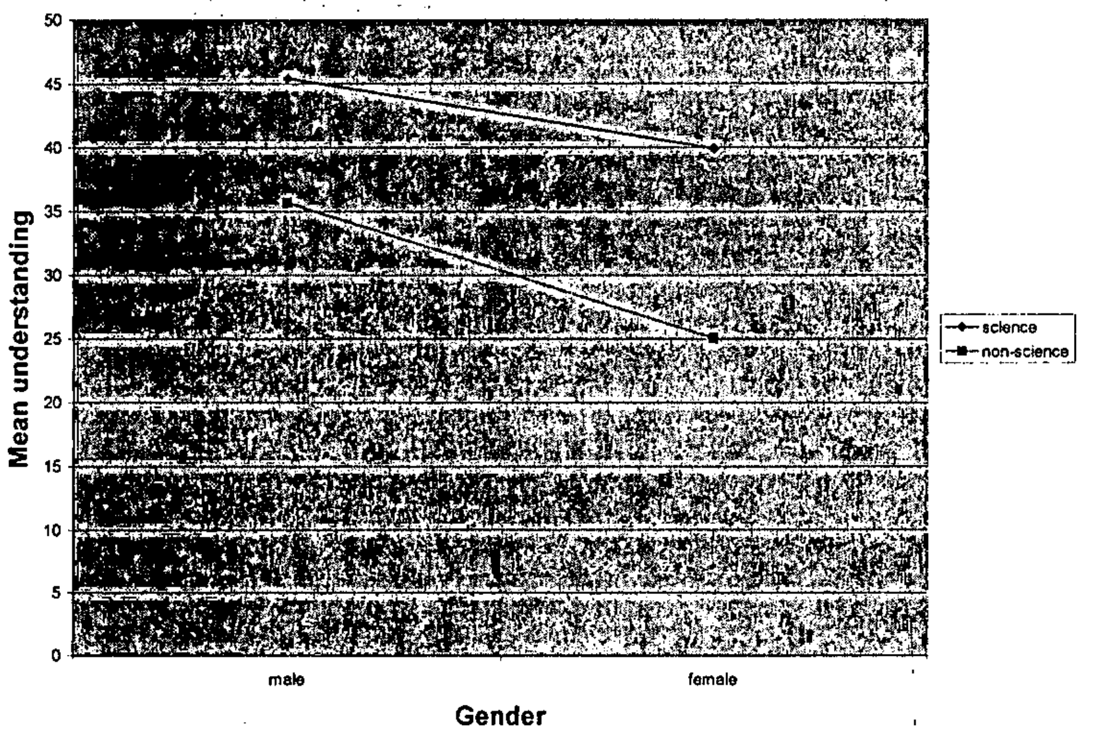


Figure 4.8: Interaction Effect of Subject Specialization and Gender on Students' Understanding

Figure 4.8 shows that the science students performed better in understanding both among the males ($\bar{x}$ = 45.42) and females ($\bar{x}$ = 39.91) than the non-science males ($\bar{x}$ = 35.69) and females ($\bar{x}$ = 25.07). This is another ordinal interaction effect.

Ho6c: There is no significant difference between the science and non-science students' application of selected biology concepts among those who are males and females after exposure to the experimental and control groups.

From Table 4.8, there is no significant interaction effect of subject specialization and gender on students' application of selected biology concepts (F(1,657) = 0.942;p>.05). Hence, hypothesis 6c is not rejected.

Ho7a: There is no significant difference in the students' knowledge of selected biology concepts among those who are males and females in science and non-science classes exposed to the experimental and control groups.

Table 4.4 showed that the 3-way interaction effect of treatment, subject specialization and gender on students' knowledge is not significant (F(1,657) = 2.262;p>.05). Hence, hypothesis 7a is not rejected.

Ho7b: There is no significant difference in the students' understanding of selected biology concepts among those who are males and females in science and non-science classes exposed to the experimental and control groups.

From Table 4.6 the 3-way interaction effect of treatment, subject specialization and gender on students' understanding is significant (F(1,657) = 11.215;p<.05). Therefore, hypothesis 7b is rejected.

Ho7c: There is no significant difference in the students' application of selected biology concepts among those who are males and females in science and non-science classes exposed to the experimental and control groups.

Table 4.8 showed that there is no significant 3-way interaction effect of treatment, subject specialization and gender on students' application of selected biology concepts ($F(1,657) = 2.912; p>.05$). Hence, hypothesis 7c is not rejected.

4.3.0 Summary of Findings

Findings of this study are summarized below:

1. Students taught by using the Mercedes Model with Embedded Assessment Strategy performed better in knowledge, understanding and application of selected biology concepts than those taught by using the conventional teaching method.

2. The science group consistently performed better than their counterparts in the non-science group on knowledge, understanding and application of selected biology concepts.

3. Gender did not affect students' understanding and application of selected biology concepts but however, it did affect students' knowledge of selected biology concepts in both the experimental and control groups.

4. Science students performed better in knowledge, understanding and application of selected biology concepts than their counterparts in the non-science groups in each of the treatment groups. In the experimental group, science student performed better than the non-science.

   The trend is the same with the control group where the science students performed better than the non-science.

5. In each of the experimental group and control group, gender did not affect students knowledge, understanding and application of selected biology concepts..

6. Among the males and females in the experimental and control groups, science students did better than the non science students in knowledge and understanding but not in application of selected biology concepts.

7. Treatment, subject specialization's and gender did not affect students' knowledge and application of selected biology concepts but affected students' understanding of selected biology concepts.

CHAPTER FIVE

DISCUSSIONS OF FINDINGS

5.1.0 Discussions of Findings

In the course of this study, the following research questions were raised.

(i) Will the Mercedes Model with Embedded Assessment Strategy enhance students' knowledge, understandings and application of selected biology concepts?

(ii) Will students' subject specialization influence their knowledge, understanding and application of selected biology concepts?

(iii) Does gender influence students' knowledge, understanding and application of selected biology concepts?

(iv) Will there be a significant interaction effect of treatment and subject specialization on students' knowledge, understanding and application of selected biology concepts?

(v) Is there a significant interaction effect of treatment and gender on students' knowledge, understanding and application of selected biology concepts?

(vi) Is the interaction effect of subject specialization and gender significant on students' knowledge, understanding and application of selected biology concepts?

(vii) Will there be a significant interaction effect of treatment, subject specialization and gender on students' knowledge, understanding and application of selected biology concepts?

5.1.1 Mercedes Model with Embedded Assessment

Will the Mercedes Model with Embedded Assessment Strategy enhance students'knowledge, understanding and application of selected biology concepts?

This study revealed that there was a significant effect of the Mercedes Model with Embedded Assessment Strategy on students' knowledge, understanding and application of selected biology concepts. The Mercedes Model with Embedded Assessment Strategy group was significantly better in cognitive achievement mean score than the conventional groups. One logical reason for this lies in the utility of the Mercedes Model that points up three aspects of teaching for understanding and application of knowledge: building a knowledge base, generating understanding and finding application. Another feature of this model is that it helps teacher to comprehend that each of these three components of learning for understanding and application requires different teaching strategies. According to Gallagher (2000), one feature that resonates with teachers is that traditional practice addressed one feature of teaching for understanding and application. Teachers have always helped students to acquire an essential base of knowledge only and have not gone beyond this point. The Mercedes Model however, goes beyond this level as has been observed in the results which proved that students' understanding and application greatly improved with the use of the strategy.

Another research finding for the positive effectiveness of the Mercedes Model of instruction includes its overlay of Embedded Assessment which helps teachers:

(a) Obtain information about students' idea and reasoning while they are learning science.

(b) Interpret and make sense of this information so that teachers can understand the difficulties that students encounter during the learning process that impede understanding and;

(c) Determine the next instructional steps that will lead to improvement in understanding and application of the knowledge.

This finding is in line with Gallagher (2000), Black and William (1998b), Black and William (1998a), Bell (2000), Black and Harrison (2001), Cobern (1996).

5.1.2 Subjects Specialization and Knowledge, Understanding and Application of Biology Concepts

Will students' subject specialization influence their knowledge, understanding and application of selected biology concepts in the experimental and control groups?

There was a significant effect of subject specialization on students' knowledge, understanding and application of selected biology concepts in the experimental and control groups.

In Nigerian secondary schools, it is common practice that most students choose biology either as one of the science subjects in addition to Chemistry and/or Physics or as the only science subject they offer. Most of the non-science students (Arts and Commercial students) choose biology not because of the 'love' or interest for the subject but because they see it as the easiest science subject when compared with chemistry and physics because of the minimal mathematical calculation in the subject. Many students in the non-science class (Arts and Commercial) see biology as being forced through their throat since the SSSCE regulations stipulate that they offer one science subject. Hence, they have a mind set of doing a subject that has no bearing with their choice of vocation in the near future. Consequently, they go into biology classes with non challant attitude and end up not doing well. This supports Jobia's (1979) observation that difficulty in understanding generally appears to result not only in the greater anxiety but also negative feeling about the learning tasks.

CHAPTER FIVE

DISCUSSIONS OF FINDINGS

5.1.0 Discussions of Findings

In the course of this study, the following research questions were raised.

(i) Will the Mercedes Model with Embedded Assessment Strategy enhance students' knowledge, understandings and application of selected biology concepts?

(ii) Will students' subject specialization influence their knowledge, understanding and application of selected biology concepts?

(iii) Does gender influence students' knowledge, understanding and application of selected biology concepts?

(iv) Will there be a significant interaction effect of treatment and subject specialization on students' knowledge, understanding and application of selected biology concepts?

(v) Is there a significant interaction effect of treatment and gender on students' knowledge, understanding and application of selected biology concepts?

(vi) Is the interaction effect of subject specialization and gender significant on students' knowledge, understanding and application of selected biology concepts?

(vii) Will there be a significant interaction effect of treatment, subject specialization and gender on students' knowledge, understanding and application of selected biology concepts?

The biology class is always very large as though it were a Mathematics class and in most cases disproportionate to the number of teachers handling the subject (Anene, 1999). All these bottlenecks constitute the under-achievement of students in biology.

5.1.3 Gender and Knowledge, Understanding and Application of Biology Concepts

Will gender influence students' knowledge, understanding and application of selected biology concepts in the experimental and control groups?

Findings from this study reveal that the effect of gender on students' knowledge is significant in favour of males. However, gender is not significant on students' understanding and application of the selected concept where females slightly performed better than the male students. This implies that Mercedes Model is not particularly gender selective.

Differences between boys and girls have been established in the ways they tackle problems and answer question. Numerous studies among which are those of Hardin (1979) and Murphy (1982) showed that boys performed better in multiple choice test than girls, with boys being more willing to guess when they did not known an answer and girls omitting to answer such questions. This literally may explain, why, males did better than females in knowledge but not in other dependent variables i.e understanding and application.

In contrast to the picture which emerged from international studies in the 1970s and 1980s, the national surveys of performance of 11 - 13 and 15 years old pupils carried out in England, Wales and Northern Ireland by the APU in the 1980s (APU, 1988a, 1986b, 1989b) showed that performance depended on the nature of the assessment and the construct being assessed. Girls' performance was found to be superior to that of boys on practical tests which involved making and interpreting observations, whilst boys were better at applying physical science ideas.

5.1.4 Interaction Effect of Treatment and Subject Specialization

Will there be a significant interaction effect of treatment and subject specialization on students' knowledge, understanding and application of selected biology concepts?

The science group consistently performed better than their counterparts in the control group on each of the three dependent measures. This result is possible because the science students offer one or more other science subjects like Chemistry and Physics in which Diffusion and Osmosis are taught in relation to permeability, solutions and matter (Friebdler, Amir & Tamir 1987). Also, the students in the science class most often have higher academic ability than their Arts and Commercial counterparts and because they also know that they need biology to continue in their further pursuit of education, they were more positively disposed to the learning of biology and took great advantage offered by MM with EAS.

5.1.5 Interaction Effect of Treatment and Gender

Is there a significant interaction effect of treatment and gender on students' knowledge, understanding and application of biology concepts?

Results from the study show that the interaction effect of treatment and gender is not significant on students' knowledge, understanding and application hence, Mercedes Model and the conventional method are not gender sensitive or selective

5.1.6 Interaction Effect of Subject Specialization and Gender

Is the interaction effect of subject specialization and gender significant on students' knowledge, understanding and application of biology concepts?

Findings from this study show that the interaction effect of treatment and gender is not significant on students' knowledge, understanding and application.

This finding is in consonant with an analysis of gender differences in performance in science of pupils in England and Wales (Gorard et al., 2001) which shows that there are now no significant differences in attainment in science between boys and girls at both 14 + and 16+ for lower attaining pupils. Although, the study looked at only the "aggregate" mark for biology, chemistry and physics.

However, in Nigeria, numerous studies on the effects of students' gender on academic achievement abound and have not produced conclusive results. Some findings indicated that significant differences exist between the performance of male and female students while other finds showed that sex factor had not impact on students' performance. Adebayo (2002), Okeke and Ochuba (1996), Damonle (1992), Novak and Mosunola (1991), Akpan (1986), Olorundare (1989), Bank (1988) all agreed that male students have higher level of achievement in science, technology and mathematics that their female counterparts. On the contrary, Olagunju (1998) and Obianjo (2000) reported that female students' achievement in science is higher than male students. Similarly, Oladunjioye (2003) in his work on learning strategy, gender and achievement in verbal communication in the English Language found out that female students performed better than their male counterpart.

Apart from these two extremes, a range of activities should be used in science lessons as it is in the Mercedes Model with Embedded Assessment Strategy to appeal to both girls and boys. Girls need to do better at interactive, collaborative activities which draw on linguistic and imaginative abilities (Bennet, 2005).

In the same vein, a range of assessment strategies should be employed to ensure that no one strategy which favours either boys or girls predominates.

5.1.7 Interaction Effect of Treatment, Subject Specialization and Gender

Will there be a significant interaction effect of treatment, subject specialization and gender on students' knowledge, understanding and application of biology concept?

Findings from this study show that there is no significant 3 – way interaction effect of treatment, subject specialization and gender on students/ knowledge and application of the biology concepts. However, this is significant on students' understanding of the selected concepts.

5.2.0 Implications for Educational Practice

This study clearly showed that the Mercedes Model with Embedded Assessment Strategy was more effective and efficient than the conventional strategy. This implies that it is possible for students' knowledge, understanding and application of the selected biology concepts to improve to a very large extent. Hence, the current situation of poor academic performance is not the best that we can ever achieve.

The Mercedes Model with Embedded Assessment Strategy has proven its potency during this study which is a pointer to the fact that the strategy inherently possesses some ingredients which could make students more apt to study and achieve better results within the present school situation in Nigeria. It will be absurd and a misnomer for any teacher or stakeholder to think or say that the Nigerian students or education situation could not improve. Teachers now have an additional innovative strategy which will enhance teaching learning and assessment during the instructional process.

The conspicuous better performance of the science students over their non-science counterparts is very revealing. This means that science students took biology more seriously and perhaps showed more commitment to its study than those not in the science classes. It becomes an issue therefore, that certain measures need to be taken by both the teachers and government towards encouraging and making the non-science students develop a more positive attitude towards biology or limit the subject to only science students only. In view of the above, the non-science classes need more urgent and stringent measures, if they must continue to study and do well in biology.

This study has also shown that difference in achievement between male and female students was not significant, males performed better than females. This shows that we should not rest on the achievement so far recorded in closing the gap between males and females in science education but should continue until the females could do as well as the male students. As much as possible teachers need to continue to explore ways of encouraging the females in the study of biology.

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSION

6.1.0 Recommendations

This section presents some recommendations based on the findings of this study for the different stakeholders of education.

1. It is very pertinent that teachers of biology should adopt Mercedes Model with Embedded Assessment Strategy in the teaching of students in Secondary School.

2. Teachers of science subjects should go beyond teaching for factual information alone. They should embrace and imbibe teaching for understanding and application and should incorporate assessment which is continuous and formative in every stage of their teaching.

3. Curriculum developers need to develop Mercedes Model with Embedded Assessment packages for all the concepts of biology including curricular and instructional resources and develop tests and other measures of achievement.

4. The government should recommend the use of the strategy in the biology curriculum as well as other science subjects in the secondary schools.

5. Mercedes Model with Embedded Assessment should be used for teaching both science and non-science students especially biology which in a distant future will still continue to be offered by most if not all students in the senior secondary schools.

6. Mercedes Model with Embedded Assessment should be used for male and female students alike as it has proved relevant in improving the knowledge of both sexes.

7. Government should provide adequate motivation in terms of special allowances to science teachers as the effective use of Mercedes Model which is tasking require hard-work, resourcefulness and diligence on the part of the teachers.

8. Teacher Educators should include the Mercedes Model and Embedded Assessment Strategy as part of courses in methodology at the Colleges of Education as well as Faculties of Education in Nigeria Universities.

9. All schools should have laboratories for science teaching and adequate supplies of equipment and reagents for practical work in science.

Finally, using the words of Gallagher (2000), "if we are not both successful and politically astute in the near future, our opportunity will be lost as policy makers will find our efforts ineffective". Thus, the resources needed to carry out the task effectively will not be available. Therefore, we need to be both intellectually and politically wise or the present window of opportunity will close."

6.2.0 Conclusion

From the findings of this study, the use of Mercedes Model with embedded assessment strategy has positively improved students' knowledge, understanding and application of selected biology concepts (i.e diffusion and osmosis). This strategy has achieved this feat better than the conventional strategy currently in use in most of our schools.

Further, the biology students in the science class have proved their mettle better than the non-science group at imbibing the knowledge, understanding and application of biology concepts.

In the same vein, males performed better than their female counterparts but only in knowledge rather than understanding and application.

6.3.0 Contribution to Knowledge

- The Mercedes Model with Embedded Assessment Strategies (EAS) has proved to be an effective instructional package for teaching biology concepts thereby significantly improving students cognitive achievement in biology.

- Subject specialization a hitherto under researched area has been established in this study to influence students cognitive achievement in biology.

- The instructional teacher training packages in diffusion and osmosis which were developed and validated in this study for training teachers in the use of Mercedes Model with Embedded Assessment are additional innovative instructional packages which are adequate and effective in enhancing teaching for understanding and application of biology concepts.

- The study has established the effectiveness for embedding assessment into the instructional process. This procedure has great potential for improving teaching and learning of biology concepts.

6.4.0 Suggestion for Further Research

Further research is suggested in the following areas:

(i) The need for the study to be replicated in other parts of Nigeria.

(ii) Similar study to be carried out in other school subjects especially science subjects other than biology (physics, chemistry, agricultural science) at the senior secondary level.

(iii) An exploration of the feasibility of using the Mercedes Model with Embedded Assessment at other secondary school levels i.e. SSI, SSIII

(iv) Other variables apart from subject specialization and gender which may influence the workability of the Mercedes Model with Embedded Assessment should be identified and investigated.

(v) A follow-through study on the performances of SSSIII students in external examinations should be carried out.

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APPENDIX I

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN DIFFUSION (MEASID)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

Period: 80 mins. (2 periods)

SECTION A: Building Knowledge Base

When you begin to study a country, one of the first things you may do is draw a map of the country's borders. Before you can learn anything about a nation, it is important to understand where it begins and where it ends. The same principle applies to cells. Among the most important parts of a cell are its boundaries which separate the cell from its surroundings. The boundary of the cell is the cell membrane. The cell membrane regulates what enters and leaves the cell and also provides protection and support. The cell takes in food and water and eliminates wastes through the cell membrane.

Checkpoint

How does a country's border relate to a cell membrane?

____

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____ S3

Diffusion

Every living cell contains a liquid interior and is surrounded by liquid. Even in the dust and heat of a desert, the cells of cactus plants, scorpions and vultures are bathed in liquid. The cell membrane separatés the solution that surrounds the cell from the solution within the cell.

One of the most important functions of the cell membrane is to regulate the movement of molecules from one side of the membrane to the other. The cytoplasm of a cell is a solution of many different substances in water. Recall that a solution is a liquid mixture of two or more substances in which the molecules of the substances are evenly mixed. The substances dissolved in the liquids are called solutes. The concentration of a solution is the mass of solute in a given volume of solution, or mass/volume. For example, if you dissolved 12 gram of salt in 3 litres of water, the concentration of the solution would be

$$\frac{\text{Mass of solute}}{\text{Volume}} = 12g = 4g/l \quad \text{(grams/per litre)}$$

Dissolve 16grams of sugar in 4 litres of water, what would be the concentration of the solution.

S5

In a solution, molecule moved constantly. They collide with one another and tend to spread out randomly through space. As a result, the molecule tend to move from an area where they are move concentrated to an area where they are less concentrated, a process known as diffusion. (dif - FY00 - Zhun). When the concentration of the solute is the same throughout a solution, the system has reached "equilibrium". Diffusion causes many substances to move across a cell membrane but does not require the cell to use energy.

What do diffusion and equilibrium have to do with biological membrane?

Suppose two substances are present in unequal concentration on either side of a membrane as shown in figure 1:

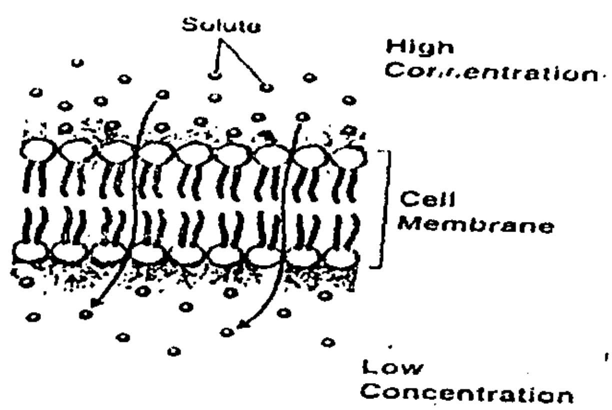

Fig. 1

The substance that can cross the membrane will tend t move towards the area where it is less concentrated until equilibrium is reached. Then, the concentration of the substance on both sides of the membrane will be the same. Even after equilibrium is reached, individual molecules continue to move rapidly across the membrane in both directions. Roughly equal numbers of molecules move in each direction, however, so there is no further change in concentration on either side.

Diffusion is the process by which molecule of a substance move from areas of higher concentration to area of lower concentration. Diffusion is also responsible for the movement.

Checkpoint

What is diffusion?

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____ S1

Look at the above diagram carefully, what does the arrow show?

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____ S2

Factors Controlling Diffusion

The rate of diffusion depends on a number of factors which include:

1. **Temperature**: Molecule diffuses faster at high temperature than at low temperature.

2. **Size of Molecule**: Small molecules diffuse faster than large ones. Thus, the smaller the molecule, the faster the rate of diffusion, while the larger the molecules, the slower the rate of diffusion.

3. **State of Matter**: Diffusion varies with the three state of manner. The diffusion of gases is much faster than that of liquids because the gas molecules are freer and therefore faster than liquid molecules.

4. **Differences in Concentration**: For diffusion to take place in a medium there must be difference in the concentration of the substance in two areas. The greater the difference in the concentration of the molecule, the greater the rate of diffusion.

Checkpoint

Does the rate of diffusion increase or decrease with temperature?

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____ S1

Look at the two bakers on the table, which beaker solution has reached equilibrium?

How do you know?

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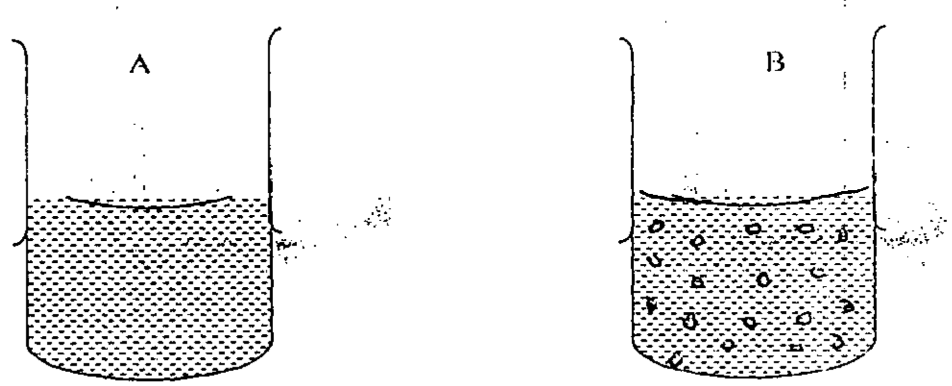
____ S4



Potassium Permanganate Potassium Permanganate

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY

IN DIFFUSION (MEASID)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

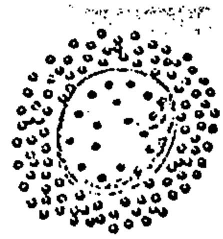
Period: 80 mins. (2 periods)

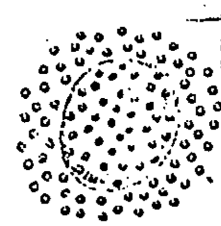
SECTION B: Generating Understanding/Making Sense/Making Generation.

Students act out the process of diffusion.

- Class members form a group at the classroom door.
- Class members spread out through the classroom in such a way that no two students are closer to each other than to the other students.
- Discussion on how molecules randomly spread out through a liquid or gas.
- Illustration of the process of diffusion using the diagram below.

Diffusion





Initially, the concentration of a substance outside the cell is higher than inside.

Later, the substance has diffused into the cell so that the concentration is same on both sides.

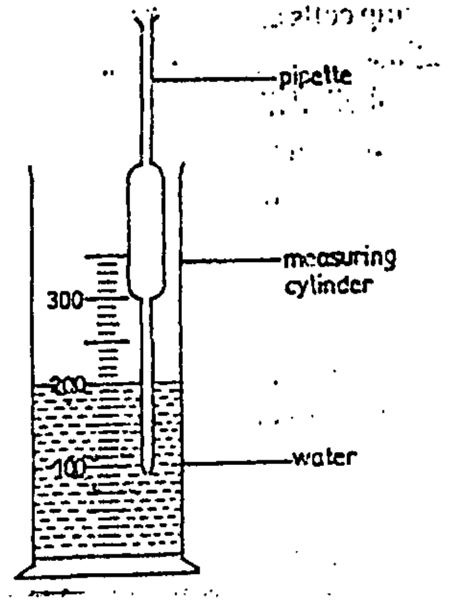
Experiment to Demonstrate Diffusion in Gases

Open a bottle of ammonia solution in a room. Move some distance away from the bottle and wait for a short while. The ammonia gas spread all around the room. Perceive the odour of air around you. The smell of ammonia gas shows that diffusion of ammonia gas has taken place.

Experiment to Demonstrate Diffusion in Liquids

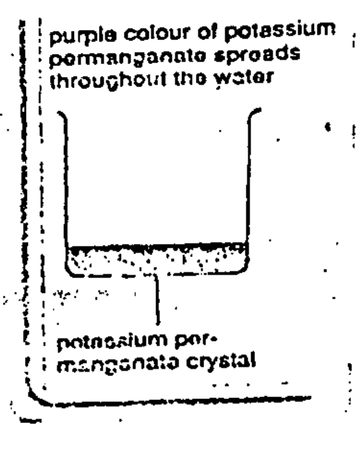
Fill a beaker with distilled water. Use pipette to drop small quantity of potassium permanganate solution gently at the bottom of the beaker and leave it to stand for few minutes. The purple colour of the potassium permanganate solution starts to spread outside.

Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade of purple colour,



Experiment to Demonstrate Diffusion in Solids

Place a crystal of potassium permanganate in a beaker of water and leave it to stand, the purple colour of the permanganate starts to spread outwards from the crystal (fig.10 - 14A). Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade or purple.



Checkpoint

How does molecule spread out in gas different from liquid? Think about classroom demonstration.

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____ S4

Some molecules diffuse across all membranes with the help of carrier protein in the membranes. This form of passive transport is called facilitated diffusion. Here, molecules move from higher concentration to lower concentration. Facilitated diffusion enables the transport of glucose from the blood into body cells.

Checkpoint

What is facilitated diffusion?

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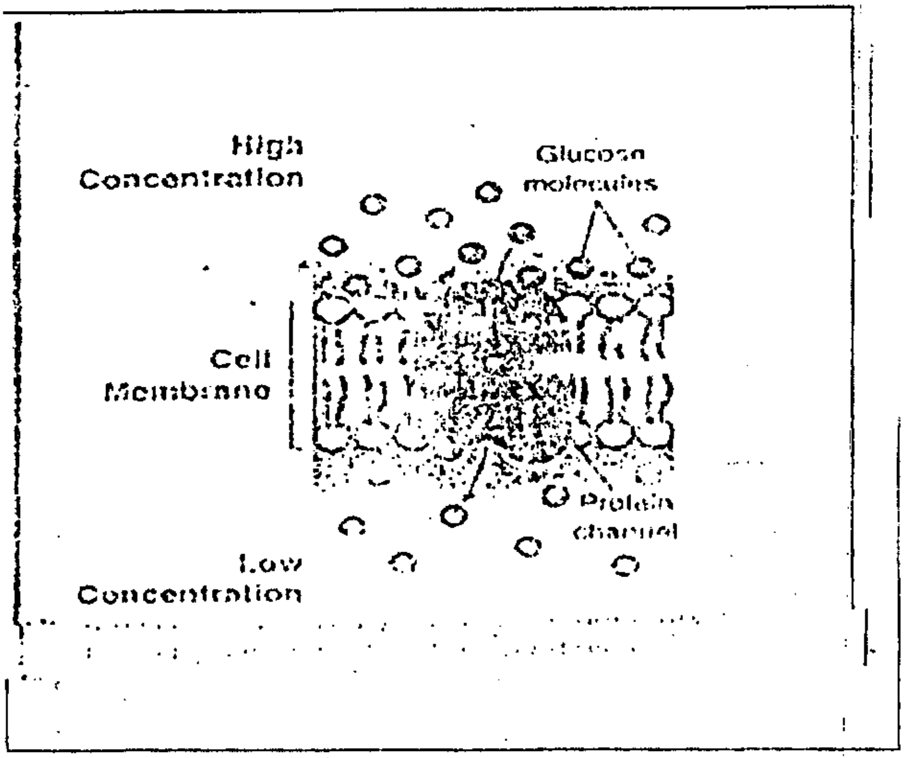
____ S1

During facilitated diffusion, molecules such as glucose that cannot cross the cell membranes lipid bilayer directly move through protein channels instead.



Checkpoint

Why does facilitated diffusion not require the cell to use energy?

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____ S1

Think about the laboratory experiment. The potassium permanganate spread faster when the water heated up why was this so?

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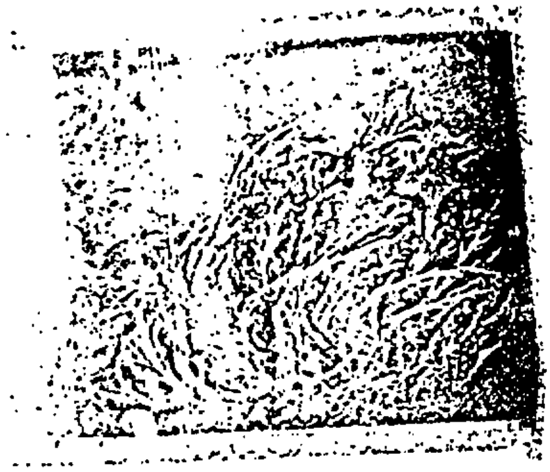
____ S5



How can a desert plant that appears brown and shriveled come back to life?

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____ S2

Why do molecules diffuse faster at high temperature? Give reason for your answer.

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____ S3

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY

IN DIFFUSION (MEASID)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

Period: 80 mins. (2 periods)

SECTION C: Finding Application

Importance of Diffusion to Flowering Plants

Diffusion is important to flowering plants in the following ways:

(i) Movement of carbon-dioxide through the stomata into the leaves during respiration.

(ii) There is movement of carbon-dioxide through the stomata into the leaves during photosynthesis.

(iii) Water vapour leaving the leaves during transpiration.

(iv) Movement of oxygen into the leaves through the stomata during respiration.

Importance of Diffusion to Animals

Diffusion plays important roles in the life of animals through the following processes:

(i) There is intake of oxygen or nutrients from mother to foetus (embryo) through placenta.

(ii) Gaseous exchange in mammals occurs in the lungs during respiration.

(iii) Gaseous exchange in many cells and organisms, e.g Amoeba takes in oxygen and gets rid of carbon-dioxide by diffusion.

(iv) There is movement of carbon-dioxide from the lung capillaries into the air sac.

Diffusion in Nature of Non-living Conditions

Diffusion is also very important in nature or non-living conditions through the following processes:

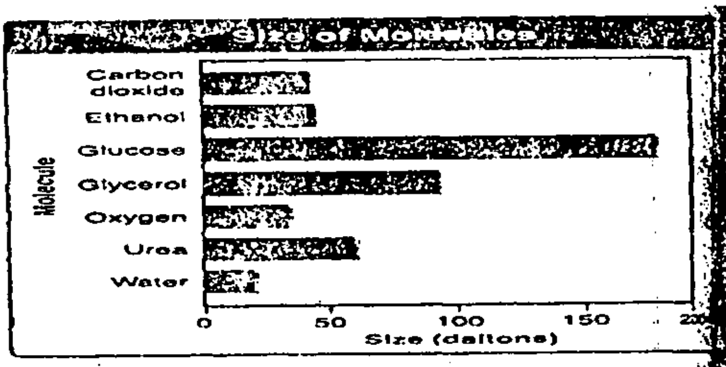
(i) The spread of the smell or odour of perfume from a person or a corner of a room.

(ii) Diffusion of molecules (gases and liquids) in iodine, potassium permanganate and copper sulphate solutions.

(iii) The spread of insecticide in a room.

(iv) The spread of the smell of gases release from the anus.

Student analyze the data below.



Crossing the Cell membrane

The cell membrane regulates what enters and leaves the cell and also provides protection and support. The core of nearly all cell membranes is a double-layered sheet called a lipid bilayer. Most materials entering the cell pass across this membrane by diffusion. The graph shows the sizes of several molecules that can diffuse across a lipid bilayer.

Checkpoint

1. Which substances do you think will diffuse across the lipid bilayer most quickly? Most slowly? Explain your answers.

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____ S2

2. Formulate a hypothesis about the relationship between molecule size and rate of diffusion?

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____ S3

3. Design an experiment to test your hypothesis?

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____ S5

4. What other factors do you think might affect the rate of diffusion?

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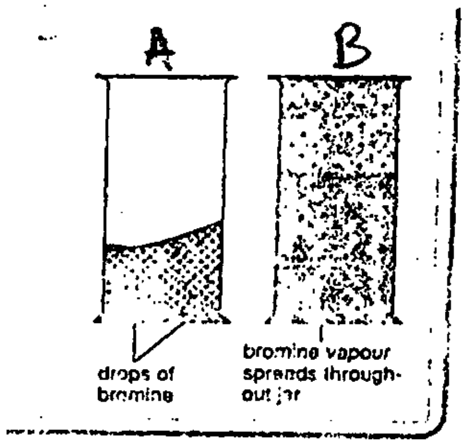
____ S1

Think about the laboratory experiment (demonstration)

Place a few drops of liquid bromine in a gas jar, cover it and leave it to stand.



Checkpoint

What has happened to the bromine molecules in Jar B?

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____ S4

APPENDIX II

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS (MEASIO)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

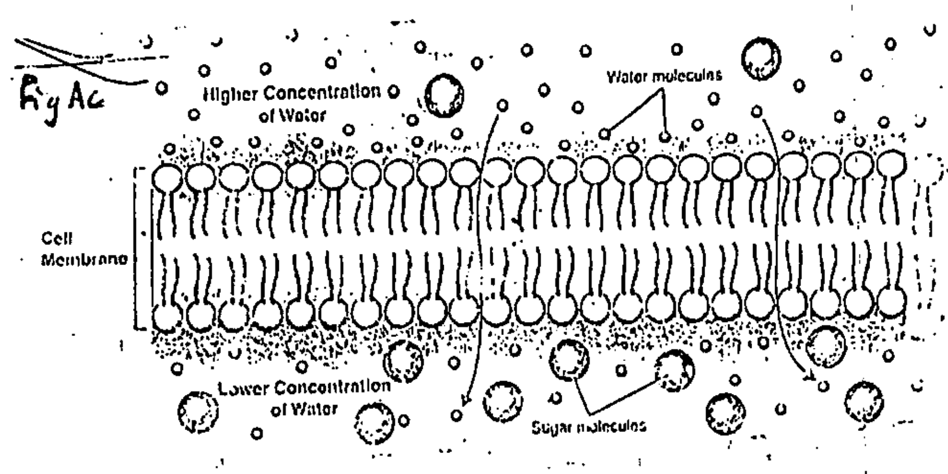
Concepts: Osmosis (what happens during Osmosis)

Period: 80 mins. (2 periods)

SECTION A: Building Knowledge Base

Osmosis

Not all substances can cross biological membranes. If a substance is able to diffuse across a membrane, the membrane is permeable (PER-mee-ub-bul) to that substance. A membrane is said to be impermeable to those things that cannot pass across it. Most biological membranes are selectively permeable, meaning that some substances can pass across them and others cannot.



Checkpoint

Using the diagram above

(a) Is this membrane permeable to water?

____ S2

(b) How does the figure AC show that there is a high concentration of water on one side of the membrane and a low concentration on the other side?

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____ S2

(c) Compare the size of water molecules and sugar molecules. What does this suggest to you?

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____ S2

A process called Osmosis allows water molecules to pass easily through most biological membranes. Osmosis is the diffusion of water through a selectively permeable membrane.

How Osmosis Works: Like the cell membrane, the membrane in figure AC is permeable to water but impermeable to sugar. There is a concentrated sugar solution on one side of the membrane and a dilute sugar solution on the other side. Although water molecules move in both directions across the membrane, there is a net movement of water into the compartment containing the concentrated sugar solution. That means more water is moving into this compartment than out of it. Why? Water, like other substances, tends to diffuse from a region where it is highly concentrated to one where it is less concentrated. The compartment with the dilute sugar solution starts out with the highest concentration of water.

Water will move across the membrane until equilibrium is reached. At that point, the concentrations of water and sugar will be the same on both sides of the membrane. When this happens, the two solutions will be isotonic, which means same "strength". When the experiment began, the more concentrated sugar solution was hypertonic, which means "above strength". The dilute sugar solution was hypotonic, or "below strength".

Conditions Necessary for Osmosis to take place

There are three major conditions which are necessary for osmosis to take place. These are:

(i) Presence of a stronger solution, e.g sugar or salt solution.

(ii) Presence of a weaker solution, e.g distill water

(iii) Presence of a selectively or differentially permeable membrane.

Living Cells as Osmometer

In Osmosis, there are usually two solutions which are separated by a differentially permeable membrane. The weaker is said to be hypotonic while the stronger solution is said to be hypertonic. When both solutions have the same concentration, they are said to be isotonic.

(i) **Hypotonic**: When a cell of a living plant or animal is surrounded by pure water or solution whose solute concentration is lower, water passes into the cell by osmosis. The solution is therefore said to be hypotonic.

(ii) **Isotonic**: When the solute concentration of the cell and its surrounding medium are the same, the solution is said to be isotonic.

(iii) **Hypertonic**: When the cell is surrounded by a stronger solution, water will be lost by the cell. The shrinking of the cell is as a result of the surrounding solution being hypertonic. In living cells, when water moves across the membrane into a solution of a higher concentration, a pressure is created in the cell. This pressure is called osmotic pressure. The solution is said to exert a higher osmotic pressure than the weaker solution. Osmotic pressure is a force that drawn in water into the cell. The pressure which a solution can potentially exert is called its osmotic potential. Osmoregulation is the control of fluctuations in the concentration of substances in cell fluids by special devices such as the contractile vacuoles in Amoeba and Paramecium.

Differences between Diffusion and Osmosis

S/N	Diffusion	Osmosis
1.	Diffusion occurs in gases and liquids	Osmosis occurs in liquid medium only
2.	Differentially permeable membrane is not required	Differentially permeable is required
3.	It occurs in living and non-living organisms	It occurs naturally in living organisms

Checkpoint

2. What is the relationship between Osmosis and Diffusion

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______________________________________ S3

3. By definition what is the only substance that can carry out osmosis?

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______________________________________ S1

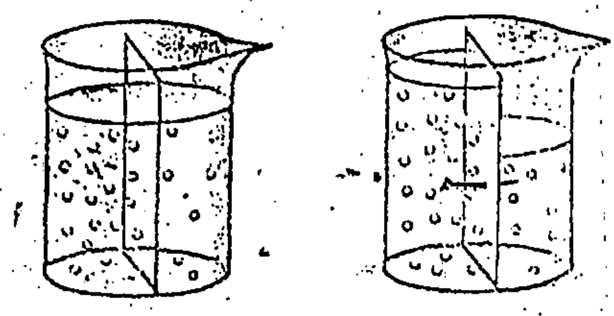

Fig. Bd

4. Think about this laboratory demonstration above.

How has the concentration of the solution changed in the beaker on the right?

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____ S4

5. * Peel a thin layer from the inner surface of a piece of a red onion.

- Place the piece of onion in the centre of a glass slide. Add a drop of water to the piece of onion and cover it with a cover slip.
- Use a dropper pipette to place a drop of concentrated salt solution at one end of the cover slip. Hold a piece of paper near the opposite edge of the cover slip. This will draw the salt solution under the cover slip.

- Observe the onion cells under the microscope under both low power and high power. Now record your observation.

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____ S5

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS (MEASIO)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

Period: 80 mins. (2 periods)

SECTION B: Generating Understanding/Making Sense/Making Connection

(i) In a beaker, stir in 10ml (2 teaspoons) of starch in 125ml of water. Pour about half of that mixture into a plastic sandwich bag and secure it with a tie.

(ii) Fill a second beaker with 250ml of water and add 15 drops of iodine.

(iii) Place the sandwich bag of water and starch into beaker of water and iodine. Note any changes after 20 minutes.

(iv) While waiting, add 8 drops of iodine to the rest of water - starch mixture in the first beaker and note any changes.

Checkpoint

1a. What colour change did you observe in the first beaker and the sandwich bags?

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____

____ S4

b. Describe the water outside the bag?

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____ S4

c. Explain what has happened in the sandwich bag containing starch and water.

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____ S4

The Effects of Osmosis in Cells

Study the Diagram

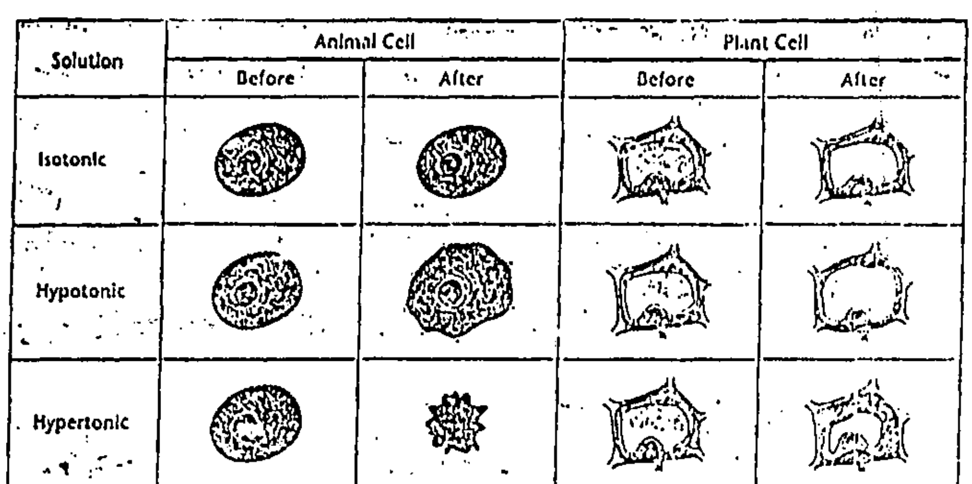

Fig. Bd

Cells placed in a isotonic solution neither gain or lose water. In a hypotonic solution, animal cells swell and burst. The vacuoles of plant cell swell, pushing the cells contents out against the cells wall. In a hypertonic solution, animal cells shrink and plant cell vacuoles collapse.

Predicting

Checkpoint

2. Look at the cell in hypotonic solution. What will happen to the cell eventually?

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____ S2

3. Predict what would happen to the animal cell in the hypertonic solutions if it were placed in pure water?

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____ S3

Osmotic Pressure: Osmosis exerts a pressure known as osmotic pressure on the hypertonic side of a selectively permeable membrane. Osmotic pressure can cause serious problems for a cell. Because the cell is filled with salts, sugars, proteins and other molecules, it will almost always be hypertonic to fresh water. That means that osmotic pressure should produce a net movement of water into a typical cell that is surrounded by fresh water. If this happens, the volume of a cell will increase until the cell becomes swollen, as shown in figure Bd. Eventually, it may burst like an over-inflated balloon.

Fortunately, cells in large organisms are not in danger of bursting. Most cells in such organisms do not come in contact with fresh water. Instead, the cells are bathed in fluids, such as blood, that are isotonic. These isotonic fluids have concentrations of dissolved materials roughly equal to those in the cells themselves. Other cells, such as plant cells and bacteria, which do come into contact with fresh water, are surrounded by tough cell walls. The cell walls prevent the cells from expanding, even under tremendous osmotic pressure. However, the increased osmotic pressure makes the cells extremely vulnerable to injuries to their cell walls.

Still other cells use a mechanism to pump out the water that is forced in by osmosis.
For example, some single-celled organisms have a structure called a contractile vacuole.
By contracting rhythmically, the contractile vacuole pumps excess water out of the cell.
This process is an example of homeostasis, the maintenance of a controlled internal environment.

Checkpoint

4. How do cell walls protect cells from osmotic pressure?

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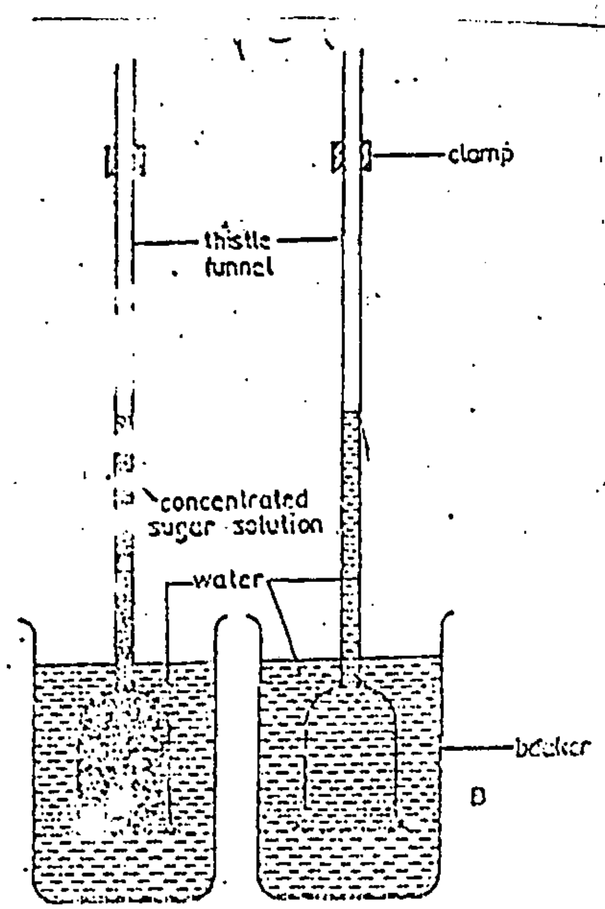
____ S1

Experiment I

Aim: To demonstrate osmosis using a non living material



Materials required: Two thistle funnel, beakers, sugar solution, water, pig bladder or cellophane paper.

Method: Pour equal quantity of water into the beaker, then cover the bottom of the thistle funnels with cellophane paper (selectively permeable membrane). Then pour sugar solution into thistle funnel A and water into thistle funnel B (control experiment) and mark their levels. Then, immerse the two funnels into the beakers containing water (fig.12.3). Allow the experiment to remain for 2 - 3 hours.

Observation: At the end of the experiment, the volume of sugar solution will rise in the thistle funnel A while the water level in the beaker will reduce. At the same time, the volume of the water in funnel B and beaker remain at the same level.

Conclusion: The rise of sugar solution in thistle funnel A and decrease in the water level in the beakers show that osmosis has taken place.

Experiment II on Osmosis using living tissue group work

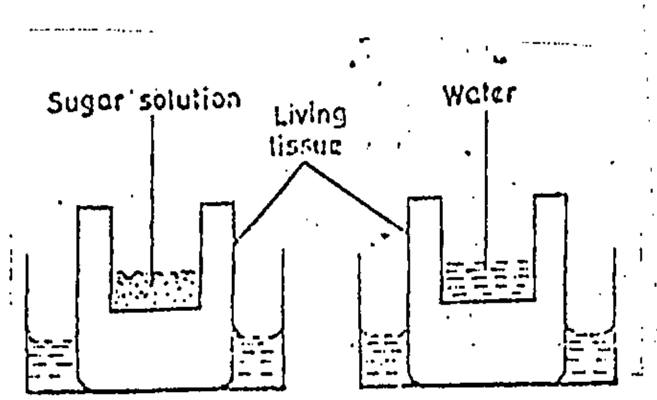


Fig. Gh: Experiment on Osmosis using a living tissue

Materials required: Yam tuber, sugar solution, water, knife, Petri-dishes.

Method: Peel the yam tuber, cut it into two parts, make a cavity with the aid of the knife into the two cut yam tubers. Pour water into the two Petri-dishes. Place each half of the yam tubers with base down into the Petri-dishes.

Think about the experiment on osmosis using a living tissue.

Checkpoint

5. Why did the water in the yam cavity B remain the same?

____

____

____ S5

MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS (MEASIO)

Student's Name: ....

School: .... Sex: M/F ....

Status: Non Science/Science Students

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

Period: 80 mins. (2 periods)

SECTION C: Finding Application

Teachers and Students discuss: Importance of Diffusion to Flowering Plants

Consider this real-life circumstance. A homeowner contracts a lawn company to add fertilizer to the lawn in order to make the grass grow better. This process is normally done by spraying a mixture of fertilizer and water onto the lawn.

1a. What would happen if too much fertilizer and too little water were sprayed onto the lawn?

____

____

____ S1

b. Can you suggest what happened to the cells of the grass?

____

____

____ S1

c. In that cases, was the fertilizer-water mixture hypotonic or hypertonic compared to the grass cells?

____

____

____ S1

d. State one importance of osmosis to plants and animals.

____ S1

PLASMOLYSIS

Plasmolysis is defined as the outward movement or flow of water from living cells when they are placed in a hypertonic solution. Plasmolysis is often regarded as the opposite of osmosis. The process of plasmolysis involves the withdrawal of water from living cells up to the extent that it will result in the pulling away of the cytoplasm from the cell membrane or cell wall. As a result of this, the cytoplasm will shrink and the whole cell will collapse. When this happens, the cells are said to be plamolysed. This will eventually lead to wilting or death of the plant.

Process of Plasmolysis in Plant Cell

When a living plant cell is placed or surrounded by a sugar or salt solution, a more concentrated or hypertonic solution than the cell sap, water will be lost from the cell to the stronger solution resulting in exosmosis. As a result of this, the vacuole will shrink, pulling the cytoplasm away from the cell wall or membrane.

Teacher carried out a demonstration on Plasmolysis

Experiment to Demonstrate Plasmolysis using Spirogyra Filament

Place a piece of Spirogyra filament on a glass slide containing few drops of water, covered with cover slip. Observe the set up under the microscope. The cells are noticed to be normal or turgid.

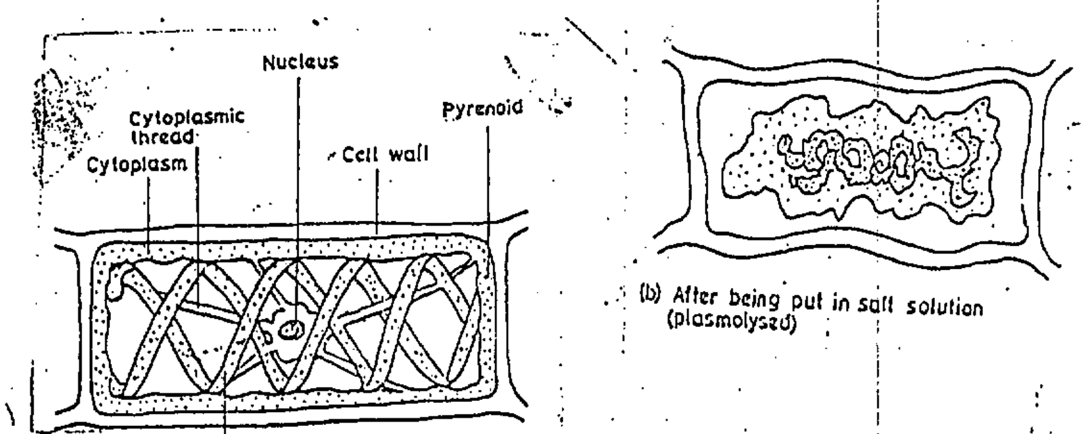


Fig. Cd: Plasmolysis in Spirogyra Filament

Add few drops of concentrated salt or sugar solution on the tissue. Leave it for 1 - 5 minutes. Observe under the microscope.

2. What has happened to the cytoplasm of the spirogyra?

____

____

____ S4

HAEMOLYSIS

Haemolysis is defined as the process by which red blood cells or corpuscles become split or burst as a result of too much water passing into it. This situation will occur when a red blood cell is placed in a weaker or hypotonic solution where the red blood cell takes in water and become swollen and may even burst.

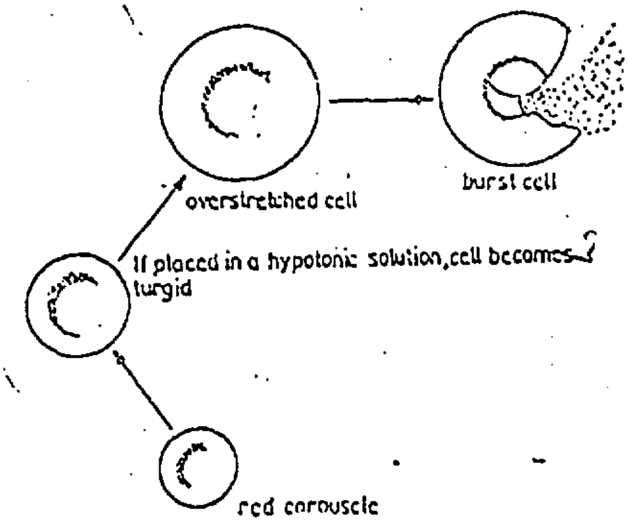


Fig. D: Haemolysis in a red blood cell or corpuscle

Use the diagram above.

3. Under what condition will the cell swell and burst?

____

____

____ S2

Experiment to Demonstrate Haemolysis using the Red Blood Cell

When the red blood cell is placed or surrounded by distilled water (hypotonic solution, water passes into the cell showing that osmosis has taken place. This results in the increase size of the cell or the cell becomes turgid or swollen (fig. De). For the fact that the distilled water is hypotonic or less concentrated than the blood cells water is absorbed by the cell. This will make the cell to swell and burst.

APPENDIX III

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN DIFFUSION

(TIG. MEASID)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHERS INSTRUCTION GUIDE (TIG)

Subject:	Biology
Date:	
Class:	Senior Secondary Year II
Topic:	Movement through Membrane
Concept:	Diffusion (What happen during diffusion)
Duration:	80 mins. (2 periods) x 3

1st and 2nd Periods

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Describe what happens during diffusion/facilitated diffusion

(ii) State factors controlling diffusion and their importance

Instructional Materials: Shriveled plants beakers, pipette etc.

Reference Books: All recommended Biology textbooks by the schools.

Entry Behaviour: Students are familiar with plant and animal cells as living units.

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Understanding

(ii) Generating Understanding

(iii) Finding Application

1st and 2nd Periods

SECTION A: Building Knowledge Base

Teachers say:

When you begin to study a country, one of the things you may do is draw a map of the country's borders. Before you can learn anything about a nation, it is important to understand where it begins and where it ends. The same principle applies to cells. Among the most important parts of a cell are its boundaries which separate the cell from its surroundings. The boundary of the cell is the cell membrane. The cell membrane regulates what enters and leaves the cell and also provides protection and support. The cell takes in food and water and eliminates wastes through the cell membrane.

Checkpoint

How does a country's border relate to a cell membrane?

A country's border separate, protect a country from other countries and regulates what comes in and leaves it like a cell membrane. S3

Diffusion

Every living cell contains a liquid interior and is surrounded by liquid. Even in the dust and heat of a desert, the cells of cactus plants, scorpions and vultures are bathed in liquid. The cell membrane separates the solution that surrounds the cell from the solution within the cell.

One of the most important functions of the cell membrane is to regulate the movement of molecules from one side of the membrane to the other. The cytoplasm of a cell is a solution of many different substances in water. Recall that a solution is a liquid mixture of two or more substances in which the molecules of the substances are evenly mixed. The substances dissolved in the liquids are called solutes. The concentration of a solution is the mass of solute in a given volume of solution or mass/volume. For example, if you dissolved 12 grams of salt in 3 litres of water, the concentration of the solution would be

$$\frac{\text{Mass of solute}}{\text{Volume}} = \frac{12g}{3L} = 4g/l \quad \text{(grams/per litre)}$$

Teacher tells students to solve the problem below:

Dissolve 16 grams of sugar in 4 litres of water, what would be the concentration of the solution?

$$\text{Concentration} = \frac{\text{Mass of solute}}{\text{Volume of solution}} = \frac{16g}{4L} = 4g/l \quad \text{S5}$$

Teacher continues

In a solution, molecule moved constantly. They collide with one another and tend to spread out randomly through space. As a result, the molecule tend to move from an area where they are more concentrated to an area where they are less concentrated, a process known as diffusion. (dif - FY00 - Zhun). When the concentration of the solute is the same throughout a solution, the system has reached "equilibrium". Diffusion causes many substances to move across a cell membrane but does not require the cell to use energy.

What do diffusion and equilibrium have to do with biological membrane?

Suppose two substances are present in unequal concentration on either side of a membrane as shown in figure 1:

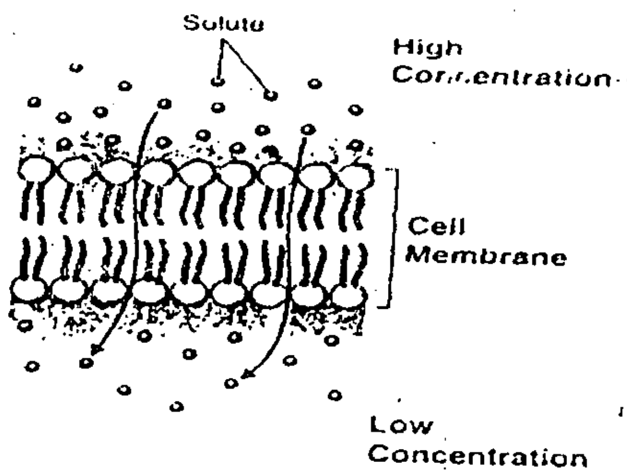


Fig. 1

The substance that can cross the membrane will tend to move towards the area where it is less concentrated until equilibrium is reached. Then, the concentration of the substance on both sides of the membrane will be the same. Even after equilibrium is reached, individual molecules continue to move rapidly across the membrane in both directions. Roughly equal numbers of molecules move in each direction, however, so there is no further change in concentration on either side.

Diffusion is the process by which molecule of a substance move from areas of higher concentration to area of lower concentration. Diffusion is also responsible for the movement.

Checkpoint

What is Diffusion?

Diffusion is the process by which molecules of a substance move from areas of higher concentration to area of lower concentration. S1

Look at the above diagram carefully, what does the arrow show?

The arrow shows molecules moving from an area of higher concentration to an area of lower concentration. S2

Teacher Explains:

Factors Controlling Diffusion

The rate of diffusion depends on a number of factors which include:

1. **Temperature**: Molecule diffuses faster at high temperature than at low temperature. High temperature increases the speed at which molecules move.

2. **Size of Molecule**: Small molecules diffuse faster than large ones. Thus, the smaller the molecule, the faster the rate of diffusion, while the larger the molecules, the slower the rate of diffusion.

3. **State of Matter**: Diffusion varies with the three state of matter. The diffusion of gases is much faster than that of liquids because the gas molecules are freer and therefore faster than liquid molecules.

4. **Differences in Concentration**: For diffusion to take place in a medium, there must be difference in the concentration of the substance in two areas. The greater the difference in the concentration of the molecule, the greater the rate of diffusion.

Checkpoint

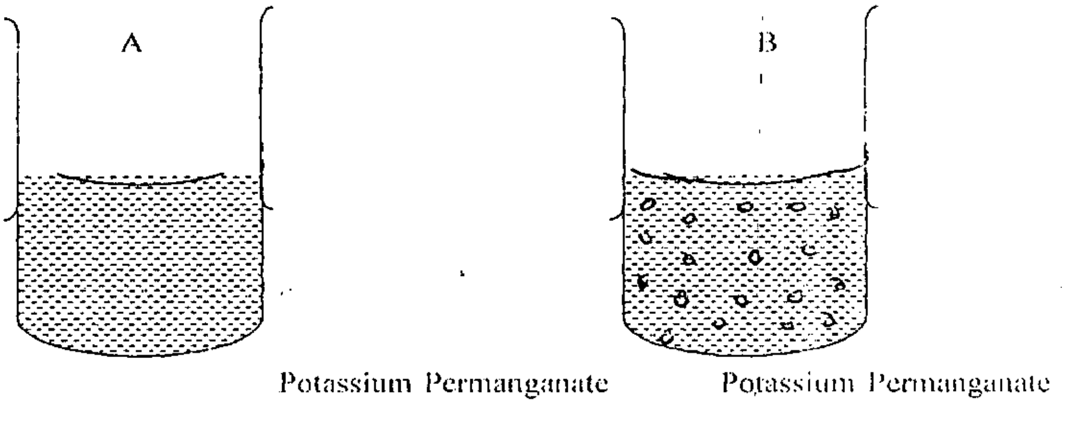
Does the rate of diffusion increase or decrease with temperature?

The rate of diffusion increases with temperature. S1

Look at the two beakers on the table, which beaker solution has reached equilibrium? How do you know?

Beaker A as reaches equilibrium because the solution is the same throughout.

S4



Teachers wraps up the Lesson

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN DIFFUSION

(TIG. MEASID)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHERS INSTRUCTION GUIDE (TIG)

Subject:	Biology
Date:	
Class:	Senior Secondary Year II
Topic:	Movement through Membrane
Concept:	Diffusion (What happen during diffusion)
Duration:	80 mins. (2 periods)

3rd and 4th Periods

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Describe what happens during diffusion/facilitated diffusion

(ii) Explain diffusion in gases, liquids and solids.

Instructional Materials: Shriveled plants beakers, pipette.

Reference Books: Modern Biology Senior Secondary Science Series and all recommended Biology textbooks by the schools.

Entry Behaviour: Students are familiar with the main functions of the cell membrane.

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Understanding

(ii) Generating Understanding

(iii) Finding Application

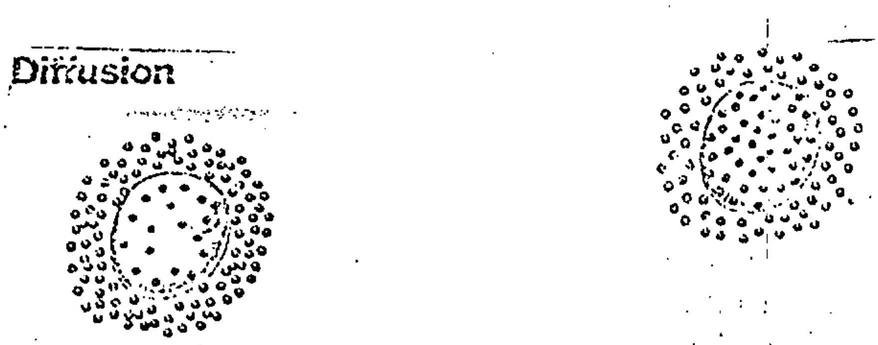
3rd and 4th Periods

SECTION B: Generating Understanding/Making Sense/Making Generation

Teacher begins by having student act out the process of diffusion

Students act out the process of diffusion.

- Class members from a group at the classroom door.
- Class members spread out through the classroom in such a way that no two students are closer to each other than to the other students.
- Discussion on how molecules randomly spread out through a liquid or gas.
- Illustration of the process of diffusion using the diagram below.



Initially, the concentration of a substance outside the cell is higher than inside.

Later, the substance has diffused into the cell so that the concentration is the same on both sides of the membrane.

Teacher does Demonstration:

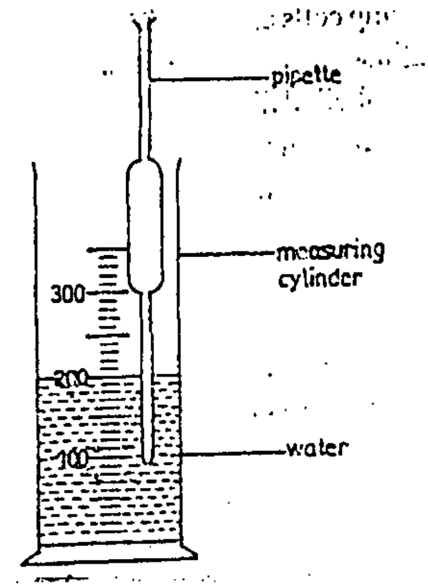
Experiment to Demonstrate Diffusion in Gases

Open a bottle of ammonia solution in a room. Move some distance away from the bottle and wait for a short while. The ammonia gas spread all around the room. Perceive the odour of air around you. The smell of ammonia gas shows that diffusion of ammonia gas has taken place.

Experiment to Demonstrate Diffusion in Liquids

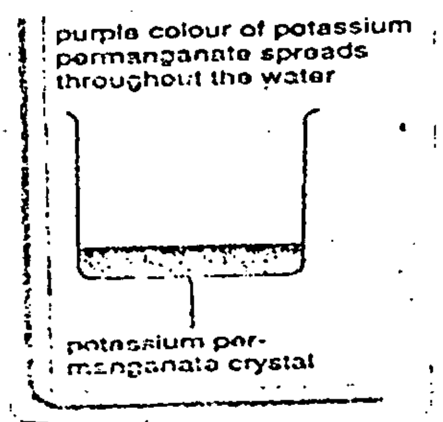
Fill a beaker with distilled water. Use pipette to drop small quantity of potassium permanganate solution gently at the bottom of the beaker and leave it to stand for few minutes. The purple colour of the potassium permanganate solution starts to spread outside.

Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade of purple colour.



Experiment to Demonstrate Diffusion in Solids

Place a crystal of potassium permanganate in a beaker of water and leave it to stand, the purple colour of the permanganate starts to spread outwards from the crystal (fig.10 - 14A). Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade or purple.



Checkpoint

How does molecule spread out in gas different from liquid? Think about classroom demonstration.

Molecule of gases are freer, hence they spread out faster than liquid. S4

Teacher continues

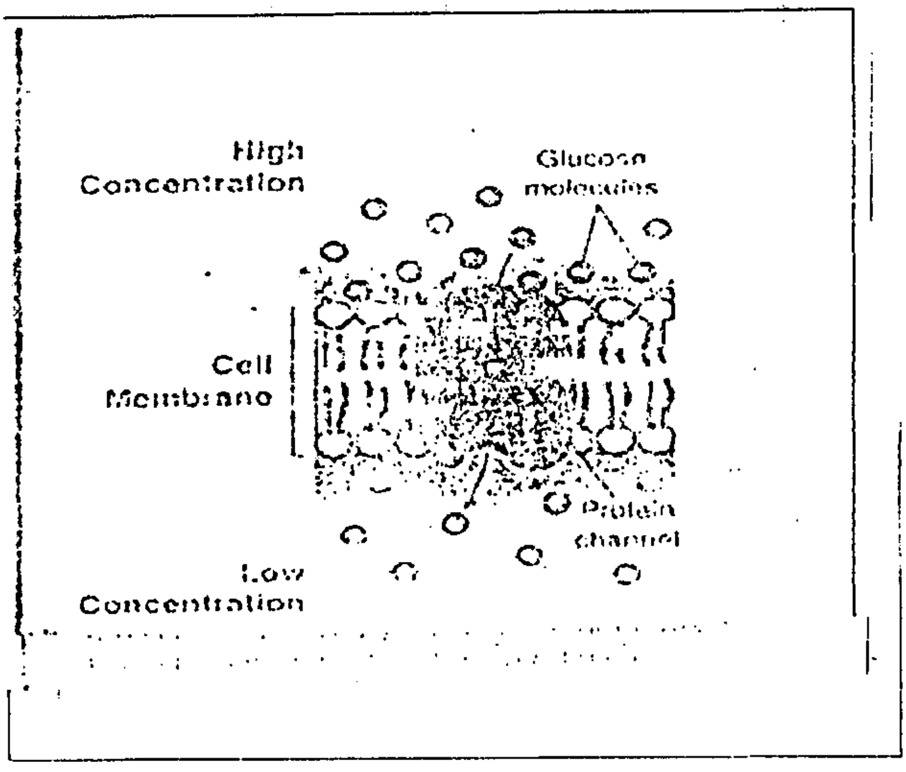
Some molecules diffuse across all membranes with the help of carrier protein in the membranes. This form of passive transport is called facilitated diffusion. Here, molecules move form higher concentration to lower concentration. Facilitated diffusion enables the transport of glucose from the blood into body cells.

Checkpoint

What is facilitated diffusion?

Facilitated diffusion is when some molecules diffuse across membrane with the help of carrier protein. S1

During facilitated diffusion, molecules such as glucose that cannot cross the cell membranes lipid bilayer directly move through channels instead.



Checkpoint

Why does facilitated diffusion not require the cell to use energy?

Facilitated diffusion does not require the cell to use energy because there are protein channels through which this molecule can cross the cell membrane. S1

Think about the laboratory experiment. The potassium permanganate spread faster when the water was heated up. Why was this so?

Diffusion increases when temperature increases. S5

How can this desert plant that appears brown and shriveled come back to life?

When rainfalls or if the desert plant is watered, water diffuses through the plant cell membrane.

S2

Why do molecules diffuse faster at high temperature? Give reason for your answer.

At high temperature, molecules are charged and move at greater speed hence diffuses faster. S3

Teacher wraps up the Lesson

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN DIFFUSION

(TIG. MEASID)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHERS INSTRUCTION GUIDE (TIG)

Subject: Biology

Date:

Class: Senior Secondary Year II

Topic: Movement through Membrane

Concept: Diffusion (What happen during diffusion)

Duration: 80 mins. (2 periods)

5th and 6th Periods

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Find application of diffusion in every day's real life processes.

Instructional Materials: Beakers, pipette.

Reference Books: Modern Biology Senior Secondary Science Series and all recommended Biology textbooks by the schools.

Entry Behaviour: Students are familiar with the main functions of the cell membrane.

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Understanding

(ii) Generating Understanding

(iii) Finding Application

5th and 6th Periods

SECTION C: Finding Application

Teacher begins by explain thus:

Importance of Diffusion to Flowering Plants

Diffusion is important to flowering plants in the following ways:

(i) Movement of carbon-dioxide through the stomata of the leaves during respiration.

(ii) There is movement of carbon-dioxide through the stomata into the leaves during photosynthesis.

(iii) Water vapour leaving the leaves during transpiration.

(iv) Movement of oxygen into the leaves through the stomata during respiration.

Importance of Diffusion to Animals

Diffusion plays important roles in the life of animals through the following processes:

(i) There is intake of oxygen or nutrients from mother to foetus (embryo) through placenta.

(ii) Gaseous exchange in mammals occurs in the lungs during respiration.

(iii) Gaseous exchange in many cells and organisms e.g Amoeba takes in oxygen and gets rid of carbon-dioxide by diffusion.

(iv) There is movement of carbon-dioxide from the lungs capillaries into the air sac.

Diffusion in Nature or Non-living Conditions

Diffusion is also very important in nature or non-living conditions through the following processes:

(i) The spread of the smell or odour of perfume from a person or a corner of a room.

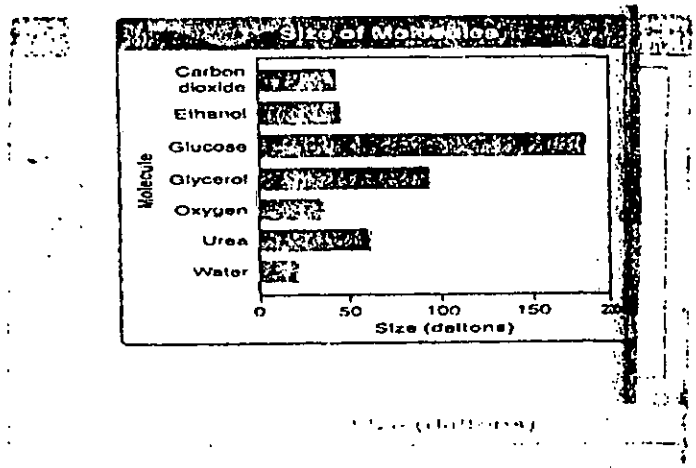
(ii) Diffusion of molecules (gases and liquids) in iodine, potassium permanganate and copper sulphate solutions.

(iii) The spread of insecticide in a room.

(iv) The spread of the smell of gases release from the anus.

Teacher continues by explaining

Student analyze the data below



Crossing the Cell membrane

The cell membrane regulates what enters and leaves the cell and also provides protection and support. The core of nearly all cell membrane is a double-layered sheet called a lipid bilayer. Most materials entering the cell pass across this membrane by diffusion. The graph shows the sizes of several molecules that can diffuse across a lipid bilayer.

Checkpoint

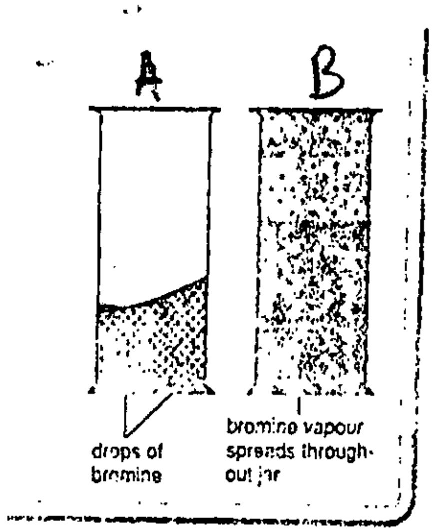
1. Using the diagram above, which substances do you think will diffuse across the lipid bilayer most quickly? Most slowly? Explain your answers. S2
2. Formulate a hypothesis about the relationship between molecule size and rate of diffusion. S3
3. Design an experiment to test your hypothesis. S5

4a. State the importance of diffusion to plants and animals. S1

b. What other factors do you think might affect the rate of diffusion? S1

Think about the laboratory experiment (demonstration)

Place a few drops of liquid bromine in a gas jar, cover it and leave it to stand.



Checkpoint

What has happened to the bromine molecules in Jar B?

The bromine molecules are well spread out in Jar B. S4

Teacher wraps up the Lesson

APPENDIX IV

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS

(TIG. MEASIO)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHERS INSTRUCTION GUIDE (TIG)

Subject:	Biology
Date:	
Class:	Senior Secondary Year II
Topic:	Movement through Membrane
Concept:	Osmosis
Duration:	80 mins. (2 periods)

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Define Osmosis

(ii) Distinguished between Osmosis and Diffusion

(iii) Explain the following terms: Hypotonic, hypertonic, isotonic solutions, Heamolysis, plassmolysis, osmotic pressure, selectively permeable membrane.

Reference Books: All other recommended biology textbooks by the schools.

Entry Behaviour: Students are familiar with the main functions of the cell membrane and can describe what happens during diffusion.

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Knowledge Base

(ii) Generating Understanding

(iii) Finding Application

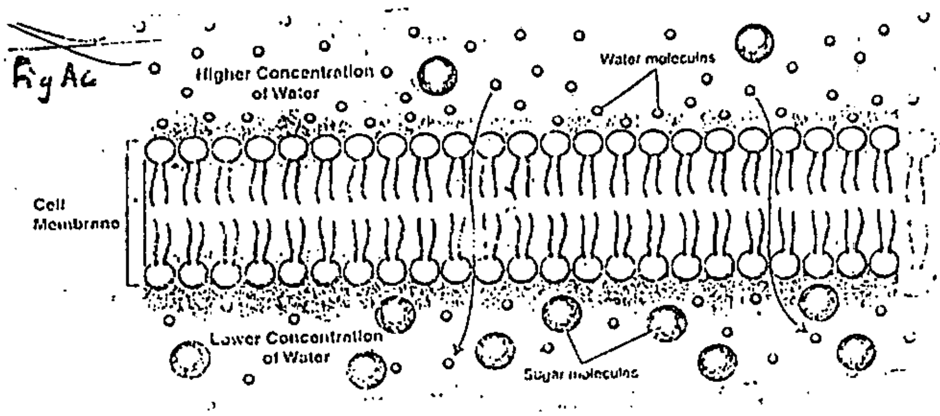
1st and 2nd Periods

SECTION A: Building Knowledge Base

Osmosis

Teacher explains thus:

Not all substances can cross biological membranes. If a substance is able to diffuse across a membrane, the membrane is permeable (PER-mee-ub-bul) to that substance. A membrane is said to be impermeable to those things that cannot pass across it. Most biological membranes are selectively permeable, meaning that some substances can pass across them and others cannot.



Checkpoint

Using the diagram above

1. Is this membrane permeable to water?

Yes, this membrane is permeable to water according to the illustration.

S2i

2. How does the figure AC show that there is a high concentration of water on one side of the membrane and a low concentration on the other side?

The bottom side has many sugar molecules mixed with water molecule and the top side has fewer sugar molecule. Therefore, there is a higher concentration of water molecule on the top side. S2ii

3. Compare the size of water molecules and sugar molecules. What does this suggest to you?

The size of sugar molecules are bigger than water molecule. S2iii

Teacher continues.

A process called osmosis allows water molecules to pass easily through most biological membranes. Osmosis is the diffusion of water through a selectively permeable membrane.

Teacher explains further:

How Osmosis Works: Like the cell membrane, the membrane in figure AC is permeable to water but impermeable to sugar. There is a concentrated sugar solution on one side of the membrane and a dilute sugar solution on the other side. Although water molecules move in both directions across the membrane, there is a net movement of water into the compartment containing the concentrated sugar solution. That means more water is moving into this compartment than out of it. Why? Water, like other substances, tends to diffuse from a region where it is highly concentrated to one where it is less concentrated. The compartment with the dilute sugar solution starts out with the highest concentration of water.

Water will move across the membrane until equilibrium is reached. At that point, the concentrations of water and sugar will be the same on both sides of the membrane. When this happens, the two solutions will be isotonic, which means "same strength". When the experiment began, the more concentrated sugar solution was hypertonic, which means "above strength". The dilute sugar solution was hypotonic or "below strength"

Conditions Necessary for Osmosis to take Place

There are three major conditions which are necessary for osmosis to take place. These are:

(i) Presence of a stronger solution, e.g sugar or salt solution

(ii) Presence of a weaker solution, e.g distill water

(iii) Presence of a selectively or differentially permeable membrane.

Living Cells as Osmometer

In Osmosis, there are usually two solutions which are separated by a differentially permeable membrane. The weaker solution is said to be hypotonic while the stronger solution is said to be hypertonic. When both solutions have the same concentration, they are said to be isotonic.

(i) **Hypotonic**: When a cell of a living plant or animal surrounded by pure water or solution whose solute concentration is lower, water passes into the cell by osmosis. The solution is therefore said to be hypotonic.

(ii) **Isotonic**: When the solute concentration of the cell and its surrounding medium are the same, the solution is said to be isotonic.

(iii) **Hypertonic**: When the cell is surrounded by a stronger solution, water will be lost by the cell. The shrinking of the cell is as a result of the surrounding solution being hypertonic. In living cells, when water moves across the membrane into a solution of a higher concentration, a pressure is created in the cell. This pressure is called osmotic pressure. The solution is said to exert a higher osmotic pressure than the weaker solution. Osmotic pressure is a force that draws in water into the cell. The pressure which a solution can potentially exert is called its osmotic potential. Osmoregulation is the control of fluctuations in the concentration of substances in cell fluids by special devices such as the contractile vacuoles in Amoeba and Paramecium.

Differences between Diffusion and Osmosis

DIFFUSION	OSMOSIS
Diffusion occurs in gases and liquids	Osmosis occurs in liquid medium only
Differentially permeable membrane is not required	Differentially permeable membrane is required
It occurs in living and non-living organisms	It occurs naturally in living organism

1. What is the relationship between Osmosis and Diffusion?

Osmosis is the diffusion of water through selectively permeable membrane. S3

2. By definition what is the only substance that can carry out osmosis?

Only water can carry out Osmosis. S1

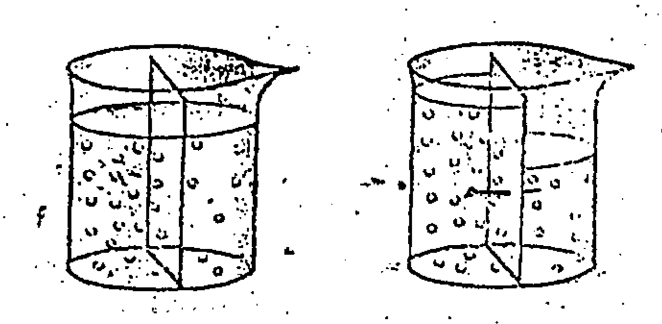


Fig. Bd

Fig. 3.19

Water moves by osmosis across a semi permeable membrane.

3. Think about this laboratory demonstration above.

How has the concentration of the solution changed in the beaker on the right?

Water has moved from solution with lower solute concentration to the solution with higher solute concentration. S4

Teacher divides student into groups to carry out the experiment on the effects of hypertonic and hypotonic solutions.

* Peel a thing layer from the inner surface of a piece of a red onion

- Place the piece of onion in the centre of a glass slide. Add a drop of water to the piece of onion and cover it with a cover slip.

- Use a dropper pipette to place a drop of concentrated salt solution at one end of the cover slip. Hold a piece of paper tower near the opposite edge of the cover slip. This will draw the salt solution under the cover slip.

- Observe the onion cells under the microscope under both low power and high power. Now record your observation.

  Student should observe that the plant cells shrink in the concentrated salt solution. S5

Teacher wraps up the Lesson

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS

(TIG. MEASIO)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHER'S INSTRUCTION GUIDE (TIG)

Subject:	Biology
Date:	
Class:	Senior Secondary Year II
Topic:	Movement through Membrane
Concept:	Osmosis
Duration:	80 mins. (2 periods)

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Demonstrate Osmosis using living/non-living materials

(ii) Explain the terms: Hypotonic, hypertonic, isotonic, heamolysis, plassmolysis, osmotic pressure, selectively permeable membrane.

Instructional Materials: Glass slides of spirogyra, egg bottle of white vinegar, beakers, starch, plastic sandwich bag, iodine, thistle funnel, sugar solution, yam tuber, knife, water, Petri-dishes.

Reference Books: All other recommended biology textbooks by the schools.

Entry Behaviour: Students are familiar with the concept of Osmosis

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Knowledge Base

(ii) Generating Understanding

(iii) Finding Application

3rd and 4th Periods

SECTION B: Generating Understanding/Making Sense/Making Connection

Teacher begins by putting up a demonstration to show Osmosis

(i) In a beaker, stir in 10ml (2 teaspoons) of starch in 125ml of water, pour about half of that mixture into a plastic sandwich bag and secure it with a tie.

(ii) Fill a second beaker with 250ml of water, and add 15 drops of iodine.

(iii) Place the sandwich bag of water and starch into beaker of water and iodine. Note any changes after 20 minutes.

(iv) While waiting, add 8 drops of iodine to the rest of water - starch mixture in the first beaker and note any changes.

Checkpoint

1. What colour change did you observe in the first beaker and the sandwich bags?

   There is a change in colour to blue black inside the sandwich bag and in the first beaker. S4

2. Describe the water outside the bag.

   The water outside the bad remain clear (because water and iodine molecule can pass through the selectivity permeable bag, whereas the starch molecule can not. S4

3. Explain what has happened in the sandwich bag containing starch and water.

   Water and iodine molecules can pass through the selectivity permeable bag, whereas the starch molecule cannot. S4

The Effects of Osmosis in Cells

Study the diagram.

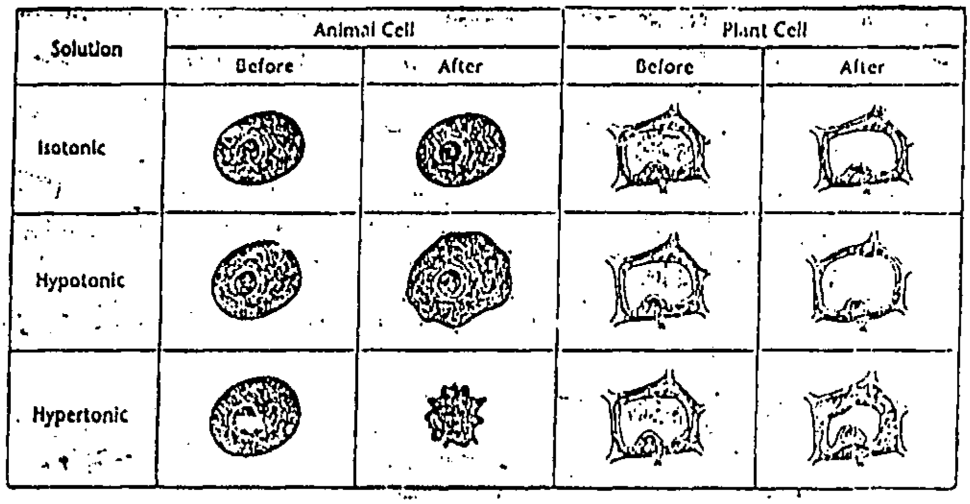


Fig. Bd

Cells placed in a isotonic solution neither gain or loss water. In a hypotonic solution, animal cells swell and burst. The vacuoles of plant cell swell, pushing the cells contents out against the cells wall. In a hypertonic solution, animal cells shrink and plant cell vacuoles collapse.

Predicting

Checkpoint

Look at the cell in hypotonic solution. What will happen to the cell eventually?

The cell will burst eventually. S2

Predict what would happen to the animal cell in the hypertonic solutions if it

Were placed in pure water?

The volume of the cell would increase until it becomes swollen. Eventually it could burst. S3

Teacher continues:

Osmotic Pressure: Osmosis exerts a pressure known as osmotic pressure on the hypertonic side of a selectively permeable membrane. Osmotic pressure can cause serious problems for a cell. Because the cell is filled with salts, sugars, proteins and other molecules, it will almost always be hypertonic to fresh water. That means that osmotic pressure should produce a net movement of water into a typical cell that is surrounded by fresh water. If this happens, the volume of a cellwill increase until the cell becomes swollen, as shown in figure Bd. Eventually, it may burst like an over inflated balloon. Fortunately, cells in large organisms are not in danger of bursting. Most cells in such organisms do not come in contact with fresh water. Instead, the cells are bathed in fluids, such as blood, that are isotonic. These isotonic fluids have concentrations of dissolved materials roughly equal to those in the cells themselves.

Other cells, such as plant cells and bacteria, which do come into contact with fresh water are surrounded by tough cell walls. The cell walls prevent the cells from expanding, even under tremendous osmotic pressure. However, the increased osmotic pressure makes the cells extremely vulnerable to injuries to their cell walls.

Still other cells use a mechanism to pump out the water that is forced in by osmosis. For example, some single-celled organisms have a structure called a contractile vacuole. By contracting rhythmically, the contractile vacuole pumps excess water out of the cell. This process is an example of homeostasis, the maintenance of a controlled internal environment.

Checkpoint

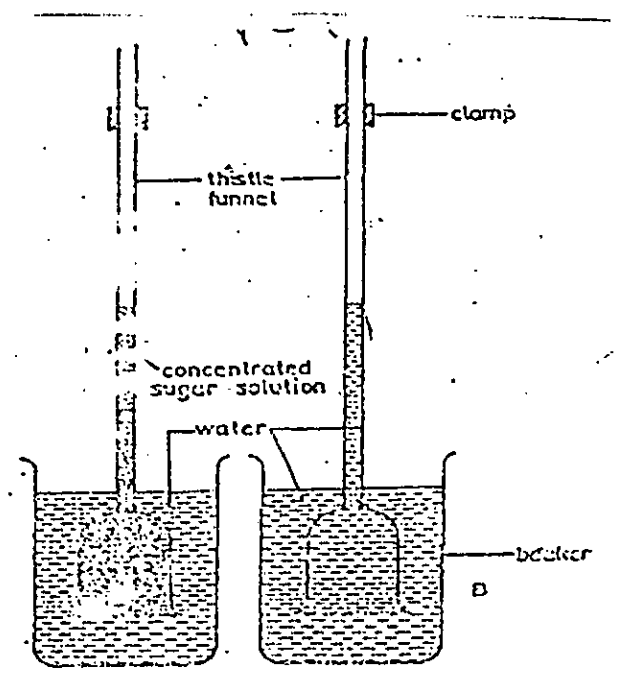
How do cell walls protect cells from osmotic pressure?

Cell walls prevent the cells from expanding even under tremendous osmotic pressure. S1

Teacher Demonstrates Osmosis using the Non-living Materials

Experiment 1

Aim: To demonstrate osmosis using a non-living material.



Materials required: Two thistle funnels, beakers, sugar solution, water, pig bladder or cellophane paper.

Method: Pour equal quantity of water into the beakers, then cover the bottom of the thistle funnels with cellophane paper (selectively permeable membrane). Then pour sugar solution into thistle funnel A and water into thistle funnel B (control experiment) and mark their levels. Then immerse the two funnels into the beakers containing water (fig.12:3). Allow the experiment to remain for 2 - 3 hours.

Observation: At the end of the experiment, the volume of sugar solution will rise in the thistle funnel A while the water level in the beaker will reduce. At the same time, the volume of the water in funnel B and beaker remain at the same level.

Conclusion: The rise of sugar solution in thistle funnels A decrease in the water level in the beakers show that osmosis has taken place.

Experiment II on Osmosis using a living Tissue Group Work

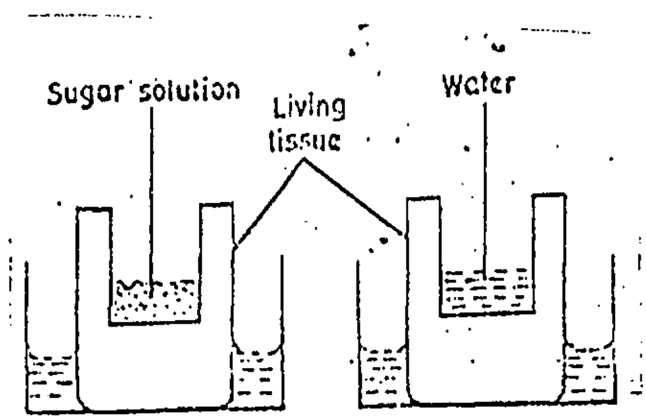


Fig. Gh: Experiment on Osmosis using a living tissue

Materials Required: Yam tuber, sugar solution, water, knife, Petri-dishes.

Method: Peel the yam tuber, cut it into two parts, make a cavity with the aid of the knife into the two cut yam tubers. Pour water into the two Petri-dishes. Place each half of the yam tuners with base down into the Petri-dishes.

Think about the experiment on osmosis using a living tissue.

Checkpoint

Why did the water in the yam cavity remain the same?

Water molecule on both side have the same concentration hence, there is no movement of water into the yam cavity. S5

Teacher Wraps up the Lesson

TEACHER'S INSTRUCTIONAL GUIDE FOR MERCEDES MODEL WITH EMBEDDED ASSESSMENT STRATEGY IN OSMOSIS

(TIG. MEASIO)

Teacher's Name: ....

School: .... Sex: M/F ....

Qualification: .... Years of Experience: ....

TEACHER'S INSTRUCTION GUIDE (TIG)

Subject: Biology

Date:

Class: Senior Secondary Year II

Topic: Movement through Membrane

Concept: Osmosis

Duration: 80 mins. (2 periods)

Instructional Objectives: At the end of the lesson, each student should be able to:

(i) Relate the process of Osmosis to similar real life processes

(ii) Explain the following terms: Hypotonic, hypertonic, isotonic, heamolysis, plassmolysis, osmotic pressure, selectively permeable membrane.

Instructional Materials: Glass slides of spirogyra.

Reference Books: Modern Biology Senior Secondary Science Series and all other recommended biology textbooks by the schools.

Entry Behaviour: Students are familiar with the main functions of the cell membrane and can describe what happens during diffusion.

Instructional Procedure: Using the Mercedes Model with Embedded Assessment Strategy.

(i) Building Knowledge Base

(ii) Generating Understanding

(iii) Finding Application

SECTION C: Finding Application

Teacher begins by explaining thus:

Consider this real-life circumstance. A homeowner contracts a lawn company to add fertilizer to the lawn in order to make the grass grow better. This process is normally done by spraying a mixture of fertilizer and water onto the lawn.

1. What would happen if too much fertilizer and too little water were sprayed onto the lawn?

   The grass would appear to be burned. S1

2. Can you suggest what happened to the cells of the grass?

They lust water because of the concentrated solution of fertilizer around them. S1

3. In that cases, was the fertilizer-water mixture hypotonic or hypertonic compared to the grass cells? s1

The mixture was hypertonic compared to the grass cells. S1

PLASMOLYSIS

Plasmolysis is defined as the outward movement or flow of water from living cells when they are placed in a hypertonic solution. Plasmolysis is often regarded as the opposite of osmosis.

The process of plasmolysis involves the withdrawal of water from living cells up to the extent that it will result in the pulling away of the cytoplasm from the cell membrane or cell wall. As a result of this, the cytoplasm will shrink and the whole cell will collapse. When this happens, the cells are said to be plasmolysed. This will eventually lead to wilting or death of the plant.

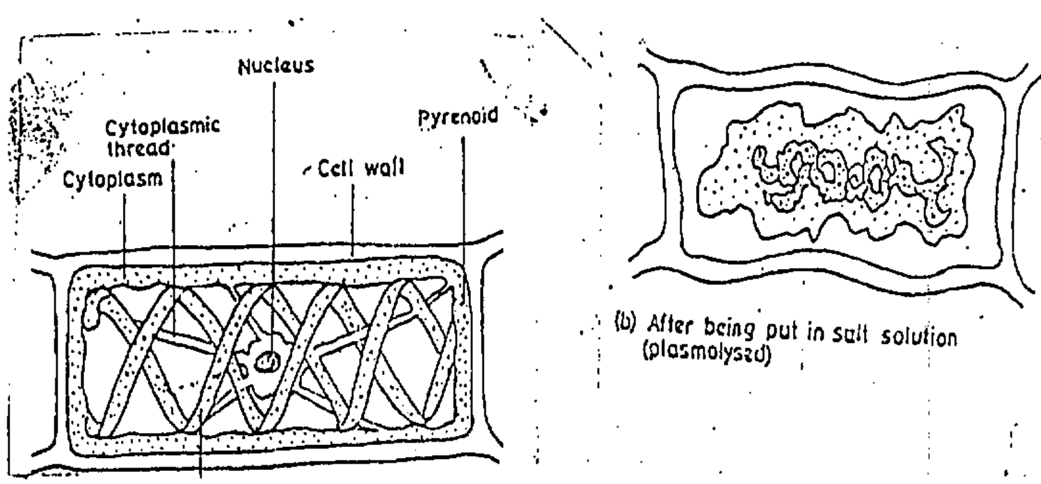
Process of Plasmolysis in Plant Cell

When a living plant cell is placed or surrounded by a sugar or salt solution. a more concentrated or hypertonic solution than the cell sap, water will be lost from the cell to the stronger solution resulting in exosmosis. As a result of this, the vacuole will shrink, pulling the cytoplasm away from the cell wall or membrane.

Teacher carries out a Demonstration on Plasmolysis

Experiment to Demonstrate Plasmolysis using Spirogyra Filament

Place a piece of Spirogyra filament on a glass slide containing few drops of water, covered with cover slip. Observe the set up under the microscope. The cells are noticed to be normal or turgid.



Chloroplast

(a) Before being put in salt solution

Fig. Cd: Plasmolysis in Spirogyra Filament

Add few drops of concentrated salt or sugar solution on the tissue. Leave it for 1 - 5 minutes. Observe under the microscope.

What has happened to the cytoplasm of the Spirogyra?

The cytoplasm has shrunk. S4

Teacher explains thus:

HEAMOLYSIS

Heamolysis is defined as the process by which red blood cells or corpuscles become split or burst as a result of too much water passing into it. This situation will occur when a red blood cell is placed in a weaker or hypotonic solution where the red blood cell takes in water and become swollen and may be burst.

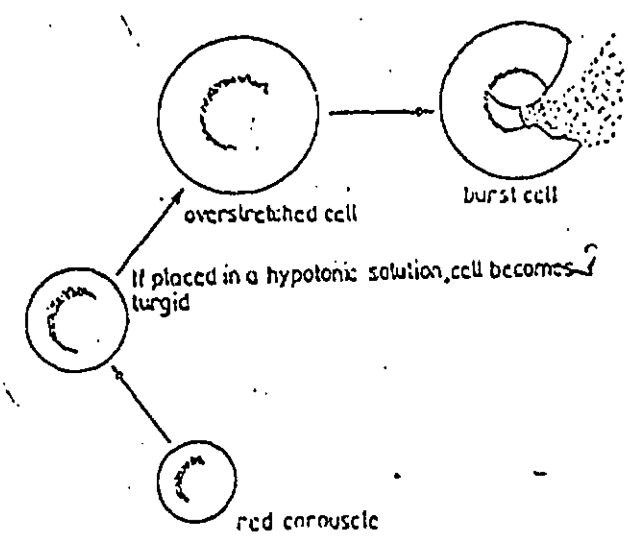


Fig. De: Heamolysis in a red blood cell or corpuscles

Use the diagram above

Under what condition will the cell swell and burst?

The cell will burst when placed in a hypotonic solution. S2

Teacher does another explanation on Heamolysis

Experiment to Demonstrate Heamolysis using the Red Blood Cell

When the red blood cell is placed or surrounded by distilled water (hypotonic solution), water passes into the cell showing that osmosis has taken place. This results in the increase in size of the cell or the cell becomes turgid or swollen (Fig. De). For the fact that the distilled water is hypotonic or less concentrated than the blood cells water is absorbed by the cell. This will make the cell to swell and burst.

Similarities and Differences between Plasmolysis and Heamolysis.

Similarities

1. They both occur in living cells
2. Both processes can lead to the death of the cells concerned.
3. Cells expand initially as more water comes into the cells in both processes.

Differences

	Plasmolysis		Heamolysis
1.	It occurs in plant cells.	(1)	It occurs in red blood cells.
2.	Plant cell shrinks.	(2)	Red blood cell bursts.
3.	It occurs in a hypertonic solution.	(3)	It occurs in hypotonic solution.

How is Plasmolysis related to Heamolysis?

Both Plasmolysis and Heamolysis occur in living cells. S3

Teacher wraps up lessons by assisting student to carry out the experiment below:

Try this		Analyze your results	
1.	Record the appearance of a raw egg in its shell. Measure and record it circumference.	(1)	Compare your recorded observations. How did the egg change? The size of the egg increased and became slippery.
2.	Gently place the egg in a jar and cover it with white vinegar. Put the lid on the jar. Record your observations.	(2)	What happened to the egg's circumference after 72 hours? The egg circumferences was increased. S5
3.	After 72 hours record the egg's appearance after being in the vinegar. Then remove the egg from the jar and measure its circumference.	(3)	What kept the contents of the egg from seeping into the vinegar? The egg hard shell kept its contents from seeping into the vinegar. S5

APPENDIX V

CONVENTIONAL LESSON PLAN ON DIFFUSION

Date:

Subject Biology

Class: S S II

Topic: Movement through the membrane

Concepts: Diffusion (what happen during diffusion)

Period: 80 mins. (2 periods) x 3

1st and 2nd Periods

Lesson Objectives: At the end of the lessons each student should be able to:

(i) Describe what happens during diffusion/facilitated diffusion.

(ii) State factors controlling diffusion and their importance.

Instructional Material:

Reference Books: All recommended biology text books by the school

Entry Behaviour: Students are familiar with plant and animal cells as living units

Content

When you begin to study a country, one of the first things you may do is draw a map of the country's borders. Before you can learn anything about a nation, it is important to understand where it begins and where it ends. The same principle applies to cells. Among the most important parts of a cell are its boundaries which separate the cell from its surroundings. The boundary of the cell is the cell membrane. The cell membrane regulates what enters and leaves the cell and also provides protection and support. The cell takes in food and water and eliminates wastes through the cell membrane.

Diffusion

Every living cell contains a liquid interior and is surrounded by liquid. Even in the dust and heat of a desert, the cells of cactus plants, scorpions and vultures are bathed in liquid. The cell membrane separates the solution that surrounds the cell from the solution within the cell.

One of the most important functions of the cell membrane is to regulate the movement of molecules from one side of the membrane to the other. The cytoplasm of a cell is a solution of many different substances in water. Recall that a solution is a liquid mixture of two or more substances in which the molecules of the substances are evenly mixed. The substances dissolved in the liquids are called solutes. The concentration of a solution is the mass of solute in a given volume of solution, or mass/volume. For example, if you dissolved 12 gram of salt in 3 litres of water, the concentration of the solution would be

$$\frac{\text{Mass of solute}}{\text{Volume}} = 12\text{g} = 4\text{g/l} \quad \text{(grams/per litre)}$$

In a solution, molecule moved constantly. They collide with one another and tend to spread out randomly through space. As a result, the molecule tend to move from an area where they are move concentrated to an area where they are less concentrated, a process known as diffusion. (dif - FY00 - Zhun). When the concentration of the solute is the same throughout a solution, the system has reached "equilibrium". Diffusion causes many substances to move across a cell membrane but does not require the cell to use energy.

What do diffusion and equilibrium have to do with biological membrane?

Suppose two substances are present in unequal concentration on either side of a membrane as shown in figure 1:

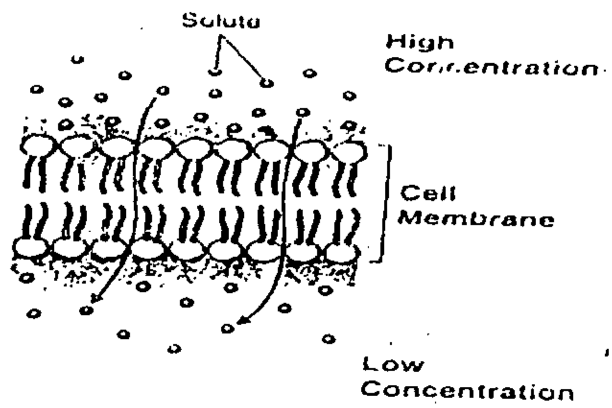


Fig. 1

The substance that can cross the membrane will tend t move towards the area where it is less concentrated until equilibrium is reached. Then, the concentration of the substance on both sides of the membrane will be the same. Even after equilibrium is reached, individual molecules continue to move rapidly across the membrane in both directions. Roughly equal numbers of molecules move in each direction, however, so there is no further change in concentration on either side.

Diffusion is the process by which molecule of a substance move from areas of higher concentration to area of lower concentration. Diffusion is also responsible for the movement.

Factors Controlling Diffusion

The rate of diffusion depends on a number of factors which include:

1. **Temperature**: Molecule diffuses faster at high temperature than at low temperature.

2. **Size of Molecule**: Small molecules diffuse faster than large ones. Thus, the smaller the molecule, the faster the rate of diffusion, while the larger the molecules, the slower the rate of diffusion.

3. **State of Matter**: Diffusion varies with the three state of manner. The diffusion of gases is much faster than that of liquids because the gas molecules are freer and therefore faster than liquid molecules.

4. **Differences in Concentration**: For diffusion to take place in a medium there must be difference in the concentration of the substance in two areas. The greater the difference in the concentration of the molecule, the greater the rate of diffusion.

Procedure:

(a) **Introduction:** Teacher uses a country's borders to explain the cell borders which separate the cell from its surrounding.

Presentation:

Step I: Teacher explains and defines diffusion

Step II: Teacher reminds students of the concept of solution and relates it to the cytolplasm of a cell.

Step III Teacher explains the factors controlling diffusion.

Step IV: Teacher asks students oral questions on the lesson.

Step IV: Students copy notes.

Evaluation: Students answer questions orally t.

(1) Define diffusion

(2) List factors controlling diffusion.

3rd and 4th Periods

Lesson Objectives: At the end of the lesson the students should be able to:

(1) Explain diffusion in gases, liquid diffusion and facilitated diffusion.

Instructional Materials: Shriveled plant, beakers etc.

Reference books: All recommended textbooks by the school.

Content

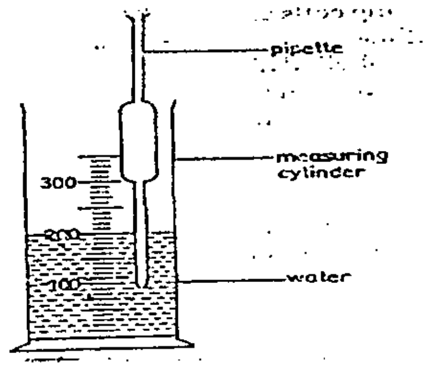
Experiment to Demonstrate Diffusion in Gases

Open a bottle of ammonia solution in a room. Move some distance away from the bottle and wait for a short while. The ammonia gas spread all around the room. Perceive the odour of air around you. The smell of ammonia gas shows that diffusion of ammonia gas has taken place.

Experiment to Demonstrate Diffusion in Liquids

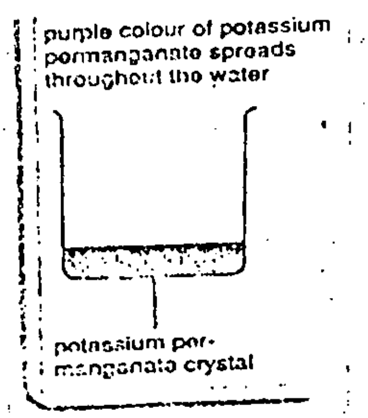
Fill a beaker with distilled water. Use pipette to drop small quantity of potassium permanganate solution gently at the bottom of the beaker and leave it to stand for few minutes. The purple colour of the potassium permanganate solution starts to spread outside.

Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade of purple colour.



Experiment to Demonstrate Diffusion in Solids

Place a crystal of potassium permanganate in a beaker of water and leave it to stand, the purple colour of the permanganate starts to spread outwards from the crystal (fig.10 - 14A). Eventually, the colour spreads evenly throughout the water medium so that the water has the same shade or purple.



Some molecules diffuse across all membranes with the help of carrier protein in the membranes. This form of passive transport is called facilitated diffusion. Here, molecules move from higher concentration to lower concentration. Facilitated diffusion enables the transport of glucose from the blood into body cells.

Procedure:

(a) **Introduction:** Teacher reviews previous lesson and explains the process of the diffusion using diagram.

Presentation:

Step I:	Teacher demonstrates diffusion in gases
Step II:	Teacher and students demonstrate diffusion in liquids.
Step III	Teacher asks student to explain diffusion in gasses and liquids
Step IV:	Teacher and students demonstrates diffusion in solids.
Step IV:	Students copy notes.

Evaluation: Students answer questions orally.

(1) What are the differences between diffusion and facilitated diffusion?

(2) Explain diffusion in liquids.

5th and 6th Periods

Lesson Objectives: At the end of the lesson, students should be able to:

(1) Find application of diffusion in every day real life processes.

(2) Answers questions on diffusion.

Instructional Materials: beakers and pipette etc.

Reference Books: All recommended textbooks by the school.

Content

Teacher and students discuss: Importance of Diffusion to Flowering Plants

Diffusion is important to flowering plants in the following ways:

(i) Movement of carbon-dioxide through the stomata into the leaves during respiration.

(ii) There is movement of carbon-dioxide through the stomata into the leaves during photosynthesis.

(iii) Water vapour leaving the leaves during transpiration.

(iv) Movement of oxygen into the leaves through the stomata during respiration.

Importance of Diffusion to Animals

Diffusion plays important roles in the life of animals through the following processes:

(i) There is intake of oxygen or nutrients from mother to foetus (embryo) through placenta.

(ii) Gaseous exchange in mammals occurs in the lungs during respiration.

(iii) Gaseous exchange in many cells and organisms, e.g Amoeba takes in oxygen and gets rid of carbon-dioxide by diffusion.

(iv) There is movement of carbon-dioxide from the lung capillaries into the air sac.

Diffusion in Nature of Non-living Conditions

Diffusion is also very important in nature or non-living conditions through the following processes:

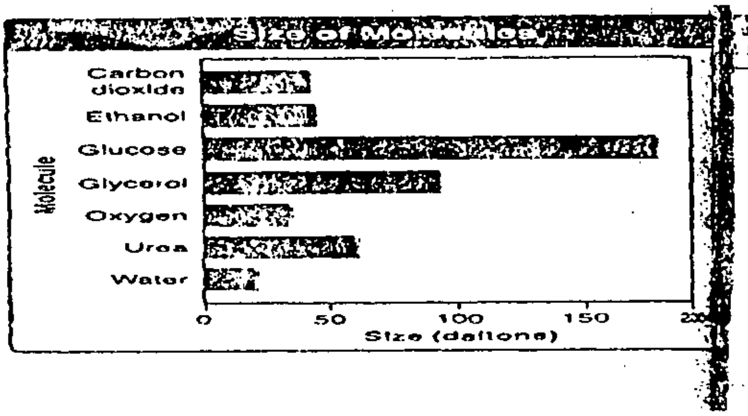
(i) The spread of the smell or odour of perfume from a person or a corner of a room.

(ii) Diffusion of molecules (gases and liquids) in iodine, potassium permanganate and copper sulphate solutions.

(iii) The spread of insecticide in a room.

(iv) The spread of the smell of gases release from the anus.

Student analyze the data below.



Crossing the Cell membrane

The cell membrane regulates what enters and leaves the cell and also provides protection and support. The core of nearly all cell membranes is a double-layered sheet called a lipid bilayer. Most materials entering the cell pass across this membrane by diffusion. The graph shows the sizes of several molecules that can diffuse across a lipid bilayer.

Procedure:

(a) **Introduction:** Teacher reviews previous lesson and discusses the importance of diffusion to flowering plants.

Presentation:

Step I: Teacher discusses diffusion in nature or non-living conditions

Step II: students analyse a graph.

Step III Teacher and students discuss crossing the cell membrane

Step IV: Students copy notes.

Evaluation: Students answer questions on diffusion (TESLOOD).

APPENDIX VI

CONVENTIONAL LESSON PLAN ON OSMOSIS

Date:

Subject Biology

Class: S S II

Topic: Movement through the membrane

Concepts: Osmosis (what happen during Osmosis)

Period: 80 mins. (2 periods) x 3

1st and 2nd Periods

Lesson Objectives: At the end this lessons the students should be able to:

(i) Define Osmosis

(ii) Distinguish between Osmosis and diffusion

(ii) Explain the following terms: hypotonic ,hypertonic, isotonic solutions.

Instructional Materials: Beakers.

Reference Books: All recommended biology textbooks by the school.

Entry Behaviour: Students are familiar with the main function of the cells membrane during diffusion.

Content

Osmosis

Not all substances can cross biological membranes. If a substance is able to diffuse across a membrane, the membrane is permeable (PER-mee-ub-bul) to that substance. A membrane is said to be impermeable to those things that cannot pass across it. Most biological membranes are selectively permeable, meaning that some substances can pass across them and others cannot.

A process called Osmosis allows water molecules to pass easily through most biological membranes. Osmosis is the diffusion of water through a selectively permeable membrane.

How Osmosis Works: Like the cell membrane, the membrane in figure AC is permeable to water but impermeable to sugar. There is a concentrated sugar solution on one side of the membrane and a dilute sugar solution on the other side. Although water molecules move in both directions across the membrane, there is a net movement of water into the compartment containing the concentrated sugar solution. That means more water is moving into this compartment than out of it. Why? Water, like other substances, tends to diffuse from a region where it is highly concentrated to one where it is less concentrated. The compartment with the dilute sugar solution starts out with the highest concentration of water.

Water will move across the membrane until equilibrium is reached. At that point, the concentrations of water and sugar will be the same on both sides of the membrane. When this happens, the two solutions will be isotonic, which means same "strength". When the experiment began, the more concentrated sugar solution was hypertonic, which means "above strength". The dilute sugar solution was hypotonic, or "below strength".

Conditions Necessary for Osmosis to take place

There are three major conditions which are necessary for osmosis to take place. These are:

(i) Presence of a stronger solution, e.g sugar or salt solution.

(ii) Presence of a weaker solution, e.g distill water

(iii) Presence of a selectively or differentially permeable membrane.

Living Cells as Osmometer

In Osmosis, there are usually two solutions which are separated by a differentially permeable membrane. The weaker is said to be hypotonic while the stronger solution is said to be hypertonic. When both solutions have the same concentration, they are said to be isotonic.

(i) **Hypotonic**: When a cell of a living plant or animal is surrounded by pure water or solution whose solute concentration is lower, water passes into the cell by osmosis. The solution is therefore said to be hypotonic.

(ii) **Isotonic**: When the solute concentration of the cell and its surrounding medium are the same, the solution is said to be isotonic.

(iii) **Hypertonic**: When the cell is surrounded by a stronger solution, water will be lost by the cell. The shrinking of the cell is as a result of the surrounding solution being hypertonic. In living cells, when water moves across the membrane into a solution of a higher concentration, a pressure is created in the cell. This pressure is called osmotic pressure. The solution is said to exert a higher osmotic pressure than the weaker solution. Osmotic pressure is a force that drawn in water into the cell. The pressure which a solution can potentially exert is called its osmotic potential. Osmoregulation is the control of fluctuations in the concentration of substances in cell fluids by special devices such as the contractile vacuoles in Amoeba and Paramecium.

Differences between Diffusion and Osmosis

S/N	Diffusion	Osmosis
1.	Diffusion occurs in gases and liquids	Osmosis occurs in liquid medium only
2.	Differentially permeable membrane is not required	Differentially permeable is required
3.	It occurs in living and non-living organisms	It occurs naturally in living organisms

Procedure

(a) **Introduction:** Teacher reviews the concept of diffusion.

Presentation:

Step I: Teacher uses the diagram of a memebrane to explain permeable and impermeable.

Step II: Teacher explains and defines Osmosis.

Step III Teacher and students discuss how Osmosis works.

Step IV: Students suggest conditions necessary for Osmosis to take place. Teacher reviews and correct their responses.

Step V: Teacher explains living cells as Osmometer using the term hypotonic, hypertonic and isotonic.

Step VI: Students and teacher compare diffusion and Osmosis.

Step VII: Students copy notes.

Evaluation: Students answer questions on

(1) Define Osmosis

(2) Compare Osmosis and diffusion

(3) Explain hypertonic, hypotonic, isotonic solutions.

3rd and 4th Periods

Lesson Objective: At the end of the lessons students should be able to:

(1) Demonstrate Osmosis using living/non living materials.

(2) Explain the following terms: Osmotic pressure and selectively permeable membrane.

Instructional Materials: Egg, bottle of white vinegar, beakers, starch, plastic sandwich bag, iodine, thistle funnel, sugar solution, yam tuber, knife, water petri diches.

Reference Books: All recommended biology textbook by the school.

Entry behavior: Students can define/explain Osmosis

Content

(i) In a beaker, stir in 10ml (2 teaspoons) of starch in 125ml of water. Pour about half of that mixture into a plastic sandwich bag and secure it with a tie.

(ii) Fill a second beaker with 250ml of water and add 15 drops of iodine.

(iii) Place the sandwich bag of water and starch into beaker of water and iodine. Note any changes after 20 minutes.

(iv) While waiting, add 8 drops of iodine to the rest of water - starch mixture in the first beaker and note any changes.

The Effects of Osmosis in Cells

Study the Diagram

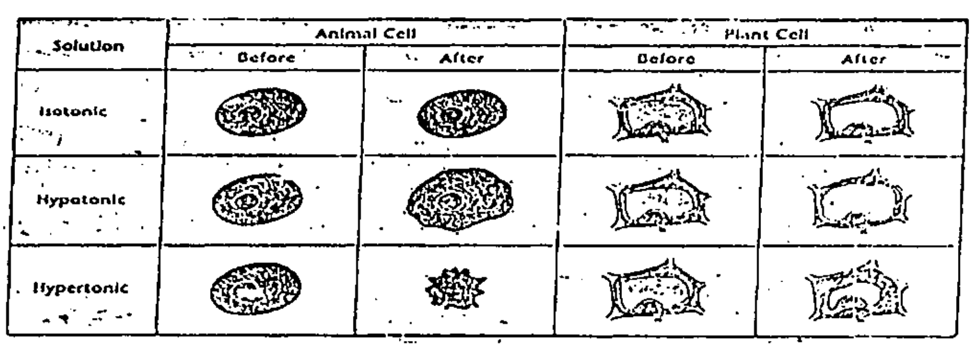


Fig. Bd

Cells placed in a isotonic solution neither gain or lose water. In a hypotonic solution, animal cells swell and burst. The vacuoles of plant cell swell, pushing the cells contents out against the cells wall. In a hypertonic solution, animal cells shrink and plant cell vacuoles collapse.

Predicting

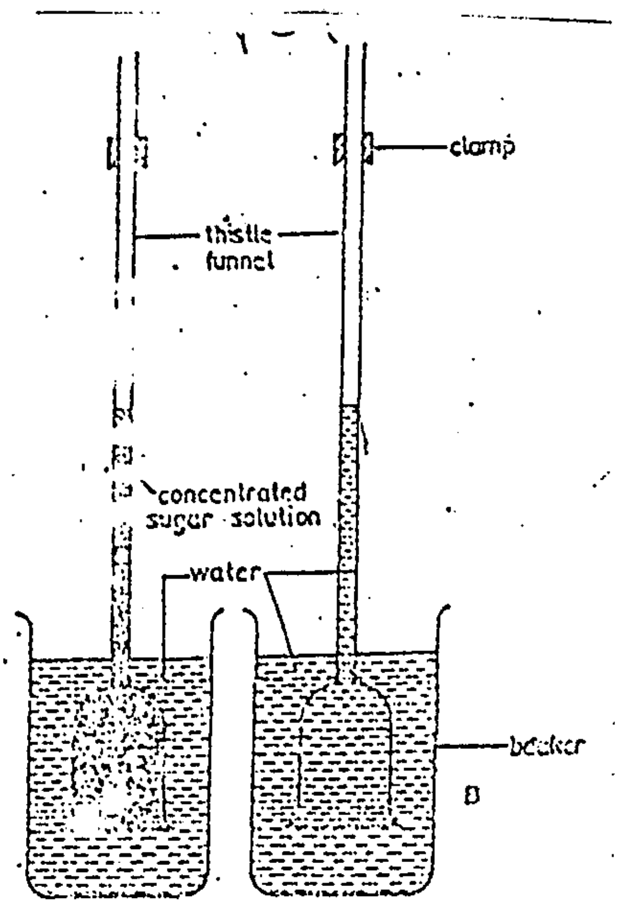
Osmotic Pressure: Osmosis exerts a pressure known as osmotic pressure on the hypertonic side of a selectively permeable membrane. Osmotic pressure can cause serious problems for a cell. Because the cell is filled with salts, sugars, proteins and other molecules, it will almost always be hypertonic to fresh water. That means that osmotic pressure should produce a net movement of water into a typical cell that is surrounded by fresh water. If this happens, the volume of a cell will increase until the cell becomes swollen, as shown in figure Bd. Eventually, it may burst like an over-inflated balloon.

Fortunately, cells in large organisms are not in danger of bursting. Most cells in such organisms do not come in contact with fresh water. Instead, the cells are bathed in fluids, such as blood, that are isotonic. These isotonic fluids have concentrations of dissolved materials roughly equal to those in the cells themselves. Other cells, such as plant cells and bacteria, which do come into contact with fresh water, are surrounded by tough cell walls. The cell walls prevent the cells from expanding, even under tremendous osmotic pressure. However, the increased osmotic pressure makes the cells extremely vulnerable to injuries to their cell walls.

Still other cells use a mechanism to pump out the water that is forced in by osmosis.
For example, some single-celled organisms have a structure called a contractile vacuole.
By contracting rhythmically, the contractile vacuole pumps excess water out of the cell.
This process is an example of homeostasis, the maintenance of a controlled internal environment.

Experiment I

Aim: To demonstrate osmosis using a non living material



Materials required: Two thistle funnel, beakers, sugar solution, water, pig bladder or cellophane paper.

Method: Pour equal quantity of water into the beaker, then cover the bottom of the thistle funnels with cellophane paper (selectively permeable membrane). Then pour sugar solution into thistle funnel A and water into thistle funnel B (control experiment) and mark their levels. Then, immerse the two funnels into the beakers containing water (fig.12.3). Allow the experiment to remain for 2 - 3 hours.

Observation: At the end of the experiment, the volume of sugar solution will rise in the thistle funnel A while the water level in the beaker will reduce. At the same time, the volume of the water in funnel B and beaker remain at the same level.

Conclusion: The rise of sugar solution in thistle funnel A and decrease in the water level in the beakers show that osmosis has taken place.

Experiment II on Osmosis using living tissue group work

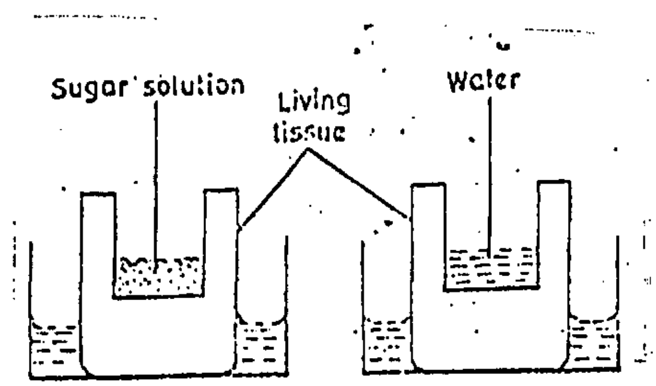


Fig. Gh: Experiment on Osmosis using a living tissue

Materials required: Yam tuber, sugar solution, water, knife, Petri-dishes.

Method: Peel the yam tuber, cut it into two parts, make a cavity with the aid of the knife into the two cut yam tubers. Pour water into the two Petri-dishes. Place each half of the yam tubers with base down into the Petri-dishes.

Procedure

(a) **Introduction:** Teacher and students review the definition of Osmosis.

(b) **Presentation:**

Step I:	Teacher does a demonstration on Osmosis (See content)
Step II:	with the aid of a diagram students and teacher discuss the effect of Osmosis in cells.
Step III	Teacher explains Osmotic pressure
Step IV:	Students with teachers assistance demonstrate Osmosis using a non living material/living material.
Step V:	Teacher reviews lessons and students copy notes

Evaluation: Students answer oral questions.

(1) Explain osmotic pressure

(2) Discuss osmosis in living material

5th and 6th Periods

Lesson Objectives: At the end of the lessons, students should be able to:

(1) Explain the following terms: heamolysis, and plasmolysis.

(2) Relate the process of Osmosis to similar real life processes.

(3) Answer questions on Osmosis.

Instructional Materials: Slides of spirogyra.

Reference Book: All recommended biology textbooks by the school.

Content:

Consider this real-life circumstance. A homeowner contracts a lawn company to add fertilizer to the lawn in order to make the grass grow better. This process is normally done by spraying a mixture of fertilizer and water onto the lawn.

PLASMOLYSIS

Plasmolysis is defined as the outward movement or flow of water from living cells when they are placed in a hypertonic solution. Plasmolysis is often regarded as the opposite of osmosis. The process of plasmolysis involves the withdrawal of water from living cells up to the extent that it will result in the pulling away of the cytoplasm from the cell membrane or cell wall. As a result of this, the cytoplasm will shrink and the whole cell will collapse. When this happens, the cells are said to be plamolysed. This will eventually lead to wilting or death of the plant.

Process of Plasmolysis in Plant Cell

When a living plant cell is placed or surrounded by a sugar or salt solution, a more concentrated or hypertonic solution than the cell sap, water will be lost from the cell to the stronger solution resulting in exosmosis. As a result of this, the vacuole will shrink, pulling the cytoplasm away from the cell wall or membrane.

Teacher carried out a demonstration on Plasmolysis

Experiment to Demonstrate Plasmolysis using Spirogyra Filament

Place a piece of Spirogyra filament on a glass slide containing few drops of water, covered with cover slip. Observe the set up under the microscope. The cells are noticed to be normal or turgid.

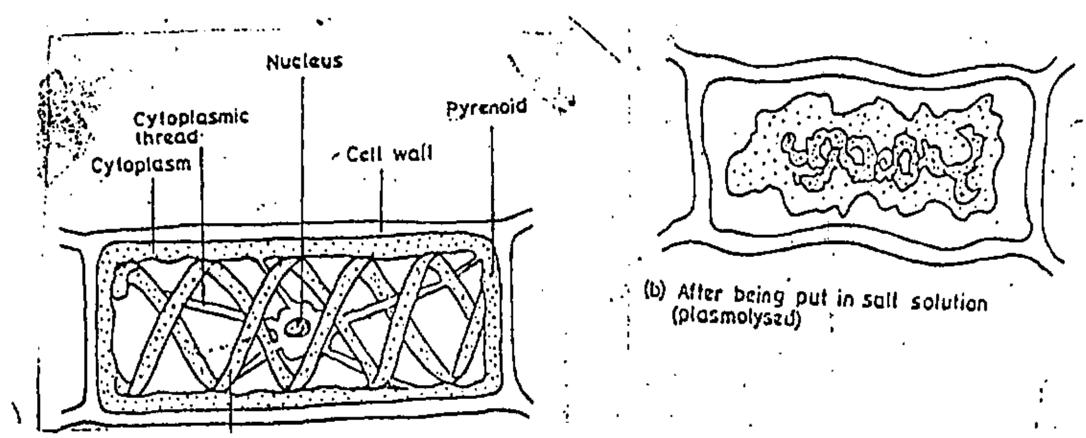


Fig. Cd: Plasmolysis in Spirogyra Filament

Add few drops of concentrated salt or sugar solution on the tissue. Leave it for 1 - 5 minutes. Observe under the microscope.

HAEMOLYSIS

Haemolysis is defined as the process by which red blood cells or corpuscles become split or burst as a result of too much water passing into it. This situation will occur when a red blood cell is placed in a weaker or hypotonic solution where the red blood cell takes in water and become swollen and may even burst.

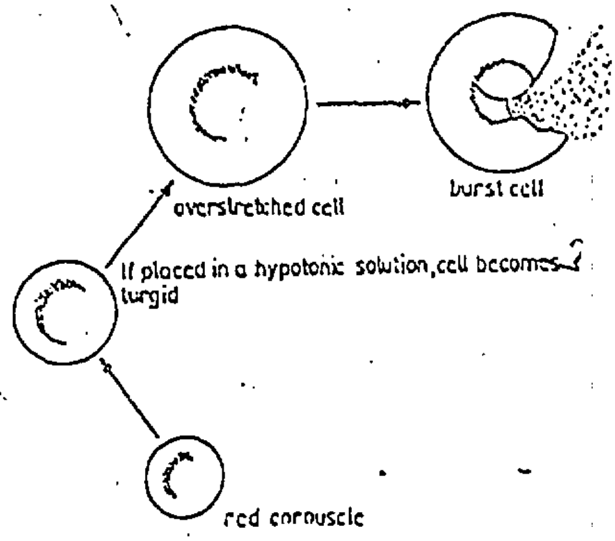


Fig. De: Haemolysis in a red blood cell or corpuscle

Experiment to Demonstrate Haemolysis using the Red Blood Cell

When the red blood cell is placed or surrounded by distilled water (hypotonic solution, water passes into the cell showing that osmosis has taken place. This results in the increase size of the cell or the cell becomes turgid or swollen (fig. De). For the fact that the distilled water is hypotonic or less concentrated than the blood cells water is absorbed by the cell. This will make the cell to swell and burst.

Similiarities and Differences between Plasmolysis and Haemolysis

Similarities

1. They both occur in living cells.

2. Both process can lead to the death of the cells concerned.

3. Cells expand initially as more water comes in to the cells in both processes.

Differences

Observing Osmosis and Semi permeability

You can observe the results of osmosis through a cell membrane when you

Try this

1. Record the appearance of a raw egg In its shell. Measure and record it Circumference.

1.Compare your recorded observations How did the egg change? The size of the egg increased and became slippery

2. Gently place the egg in a jar and cover it with white vinegar. Put the Lid on the jar. Record your observations

2. What happened to egg's circumferences after 72 hours? The egg circumference was increased

3. After 72 hours record the egg's appearance after being in vinegar. Then remove the egg from the jar its circumference

3. What kept the contents of the egg From seeping into the vinegar? The egg hard shell kept its contents from seeping into the vinegar

Procedure

(a) **Introduction:** Teacher reviews previous lesson on Osmosis

(b) **Presentation:**

Step I: Teacher illustrates and explains plasmolysis using a real life circumstance of fertilizer on plants.

Step II: Students attempt defining plasmolysis, teacher corrects students responses and gives the definition of plasmolysis.

Step III: Teacher discuses the process of heamolysis and students observe a diagram on heamolysis.

Step IV: Take home experiment

Evaluation: Students answer questions on Osmosis (TESLOOD)

APPENDIX VII

TEST ON STUDETNS LEARNING OUTCOMES IN OSMOSIS AND DIFFUSION

(TESLOOD)

Student's Name: ____

School: ____

Sex (M/F): ________ Status: Science/Non Science: ________________

SECTION A: STUDENTS KNOWLEDGE OF DIFFUSION

Answer all questions in complete sentences.

1. What do a country's border and cell membrane have in common?

____

____ S3

2. Dissolve 16 grams of sugar in 4 litres of water, what would be the concentration of the solution?

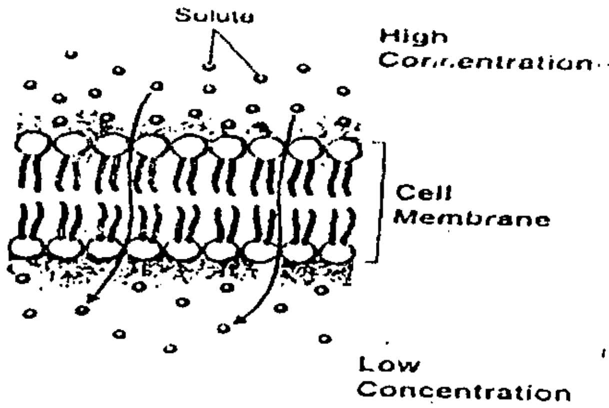
____

____ S5

3. What is diffusion?

____

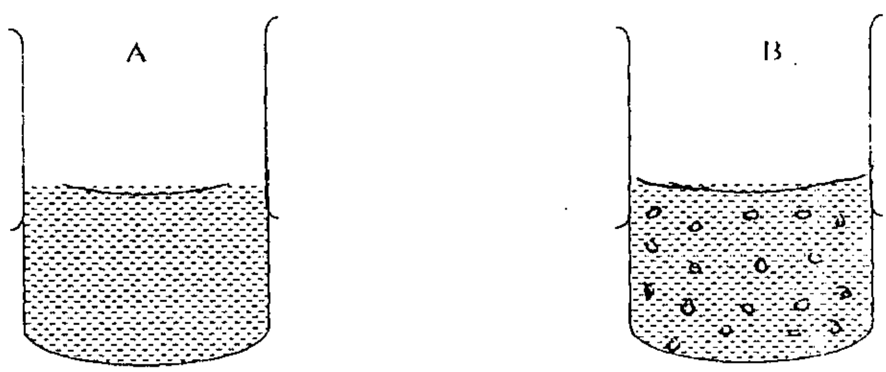
____ S1



4. Look at the above diagram carefully, what does the arrow show?

____

____ S2



Potassium Permanganate Potassium Permanganate

5. Look at the two beakers on the table, which beaker solution has reached equilibrium? How do you know?

____

____ S4

(5 x 2pts=10pts)

SECTION B: STUDENTS UNDERSTANDING OF DIFFUSION

Think about the classroom demonstration.

1. How does molecule spread out in gas different from liquid?

____

____ S4

2a. What is facilitated diffusion?

____

____ S1

b. Why does facilitated diffusion not require the cell to use energy?

____

____ S1

3. Think about the laboratory experiment. The potassium permanganate spread faster when the water has heated up, why was this so?

____

____ S5

4. How can this desert plant that appears brown and shriveled come back to life?

____

____ S2

5. Why do molecules diffuse faster at high temperature? Give reasons for your answer.

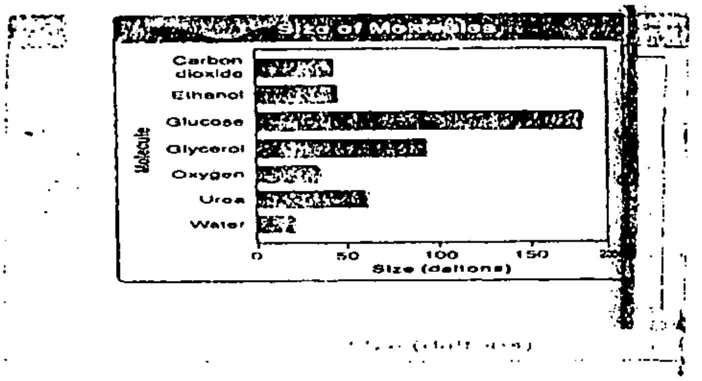
____

____ S3

(5 x 2pts=10pts)

SECTION C: STUDENTS APPLICATION OF DIFFUSION

Using the diagram above.



1. Which substance do you think will diffuse across the lips bilayer most quickly? Most slowly? Explain your answer.

____

____ S2

2. Formulate a hypothesis about the relationship between molecule size and rate of diffusion?

____

____ S3

3. Design an experiment to test your hypothesis?

____

____ S5

4a. What other factors do you think might affect the rate of diffusion?

____

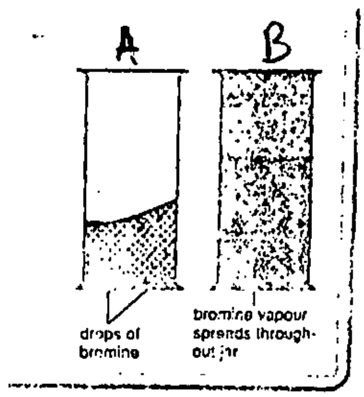
____ S1

b. State one importance of diffusion to plants and animal

____

____ S1

5. Think about the laboratory experiment (Demonstration) place a few drops of liquid bromine in a gas jar, cover it and leave it to stand.



What has happened to the bromine molecules in Jar B?

____

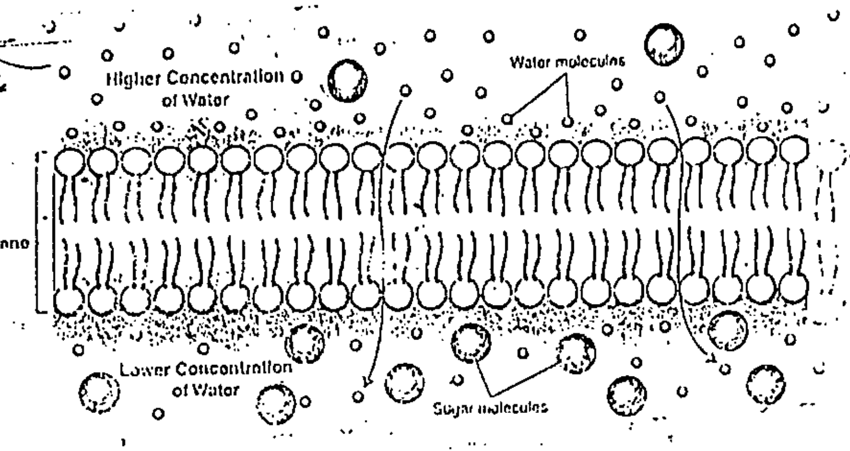
____ S4

(5 x 2pts=10pts)

SECTION A: STUDENTS KNOWLEDGE OF OSMOSIS

Answer all questions in complete sentences. Using the diagram below.

Fig AC



1a. Is this membrane permeable to water?

____

______________________________ S2

b. How does the figure AC show that there is a high concentration of water on one side of the membrane and a low concentration on the other side?

____

______________________________ S2

c. Compare the size of water molecules and sugar molecules. What does this suggest to you?

____

______________________________ S2i

2. What is the relationship between Osmosis and Diffusion?

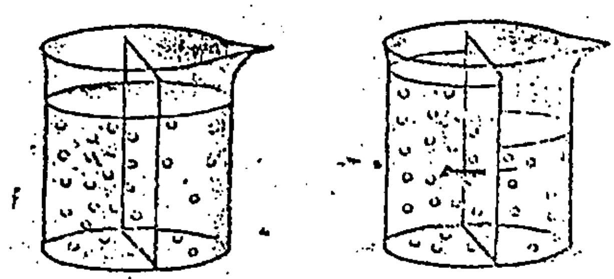
____

______________________________ S3

3. By definition what is the only substance that can carry out Osmosis?

____

____ S1



4. Think about this laboratory demonstration above. How has the concentration of the solution changed in the beaker on the right?

____

____ S4

Group work

5. Peel a thin layer from the inner surface of a piece of a red onion.

* Place the piece of onion in the centre of a glass slide, add a drop of water to the piece of onion and cover it with a cover slip.

* Use a dropper pipette to place a drop of concentrated salt solution at one end of the cover slip. Hold a piece of paper near the opposite edge of the cover slip. This will draw the salt solution under the cover slip.

* Observe the onion cells under the microscope under both low power and high power. Now record your observation.

____

____

____

____ S5

(5 x 2pts=10pts)

SECTION B: STUDENTS UNDERSTANDING OF OSMOSIS

Demonstration Experiment to show Osmosis

(i) In a beaker, stir in 10ml (2 teaspoons) of starch in 125ml of water. Pour about half of that mixture into a plastic sandwich bag and secure it with a tie.

(ii) Fill a second beaker with 250ml of water, and add 15 drops of iodine.

(iii) Place the sandwich bag of water and starch into beaker of water and iodine. (Note any changes after 20 minutes).

(iv) While waiting, add 8 drops of iodine to the rest of water-starch mixture in the first beaker and note any changes.

1a. What colour change did you observe in the first beaker and the sandwich bags?

____

____ S4

b. Describe the water outside the bag?

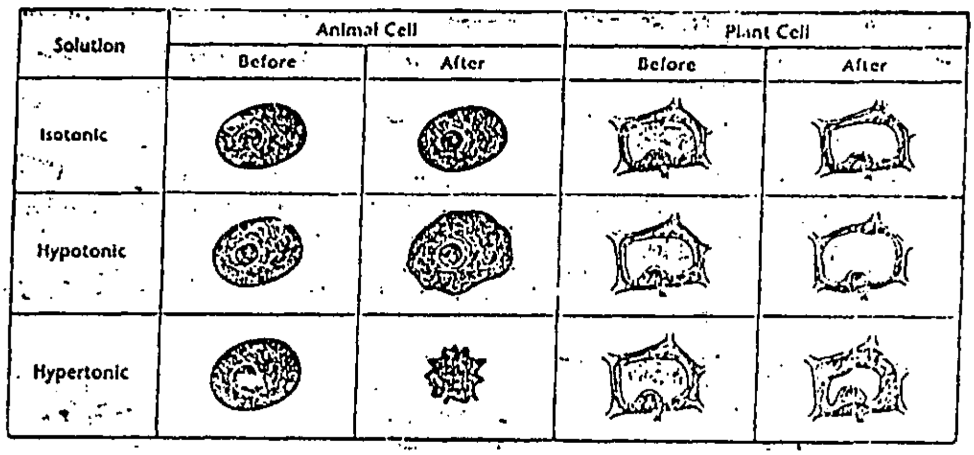
____

____ S4

c. Explain what has happened in the sandwich bags containing starch and water.

____

____ S4



2. Look at the cell in hypotonic solution, what will happen to the cell eventually?

____

____ S2

3. Predict what would happen to the animal cell in the hypertonic solutions if it were placed in pure water?

____

____ S3

4. How do cell walls protect cells from Osmotic pressure?

____

____ S1

5. Think about the experiment on osmosis using a living tissue.

Why did the water in the yam cavity B remain the same?

____

____ S5

(5 x 2pts=10pts)

SECTION C: FINDING APPLICATION

Consider this real-life circumstance. A homeowner contracts a lawn company to add fertilizer to the lawn in order to make the grass grow better. This process is normally done by spraying a mixture of fertilizer and water onto the lawn.

1a. What would happen if too much fertilizer and too little water were sprayed onto the lawn?

____

____ S1

b. Can you suggest what happened to the cells of the grass?

____

____ S1

c. In that case, was the fertilizer-water mixture hypotonic or hypertonic compared to the grass cells?

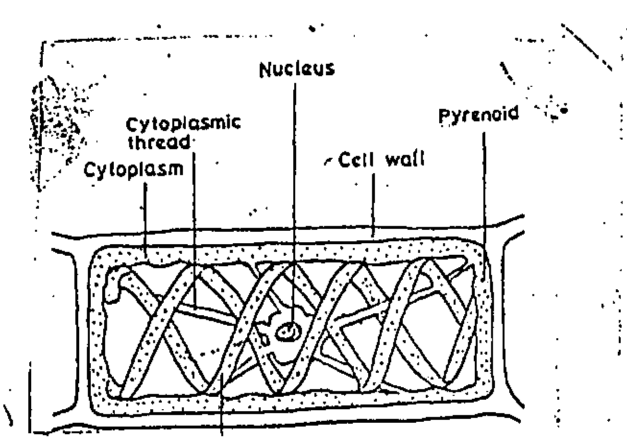
____

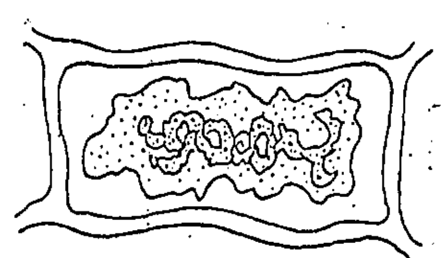
____ S1

d. State one importance of osmosis to plants and animals.

____

____ S1



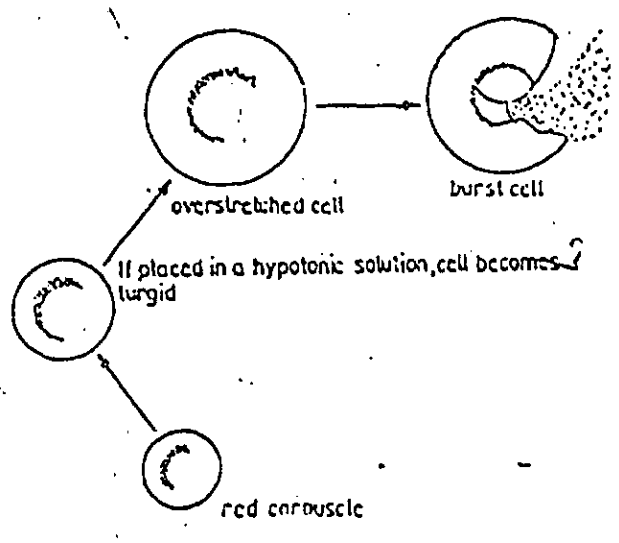


(b) After being put in salt solution (plasmolysed)

2. What has happened to the cytoplasm of the Spirogyra?

____

____ S4



3. Under what condition will the cell swell and burst?

____

____ S2

4. How is plasmolysis related to heamolysis?

____

____ S3

Try this

1. Record the appearance of a raw egg in its shell. Measure the circumference.

2. Gently place the egg in a jar and cover it with white vinegar. Put the lid on the jar. Record your observations.

3. After 72 hours record the egg's appearance after being in the vinegar. Then remove the egg from the jar and measure its circumference.

(4) Compare your recorded observations. How did the egg change?

____________________Ss

(5) What happened to the egg's Circumference after 72 hours?

____________________Ss

(6) What kept the contents of the egg from seeping into the vinegar.

____

____________________Ss

(5 x 2pts=10pts)

APPENDIX VIII

LIST OF SCHOOLS USED FOR THE STUDY

1. Lagos City Senior College, Sabo, Lagos

2. Fazl-I-Omar Senior High School, Iwaya, Lagos

3. Ayetoro Senior Grammar School, Ebute – Meta, Lagos

4. Ojota Senior High School, Ojota, Lagos

5. Immaculate Heart Senior Comprehensive High School, Maryland, Lagos

6. Ayedere Ajibola Senior High School, Ketu, Lagos