The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

University of Cape Town

UNIVERSITY OF CAPE TOWN

FACULTY OF HUMANITIES

EVALUATION OF THE DRAWINGS IN A NEW SOUTH AFRICAN TEXTBOOK FOR SCIENCE AND TECHNOLOGY: A COMPARISON BETWEEN GROUPS

University of Cape Town

A dissertation submitted to the University of Cape Town in fulfilment of the requirements for the degree of MASTER OF EDUCATION

by

KEITH RONALD JACOBS

September, 2001

The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the National Research Foundation.

DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

.....
Keith Ronald Jacobs

September 2001.

University of Cape Town

ABSTRACT

The purposes of this study are:

1) to investigate learners' and teachers' perceptions and evaluations of 40 illustrations in a new South African school textbook for Natural Science and Technology, and
2) to compare assessments of the illustrations made by different groups of users, e.g. by classes in advantaged and disadvantaged schools; learners speaking different home languages; learners of different grade levels; biology teachers compared with biology learners; and so on.

Repeated null hypotheses are used to test each dependent variable against each independent variable. These are:

1) That, when rating the **quality** of a given textbook illustration, no significant differences will occur between the expressed levels of satisfaction of two given samples of respondents (e.g. the disadvantaged and advantaged learners; the grade 8 and grade 9 learners; the high school and primary school teachers; and the science learners and the science teachers).
2) That there will be no significant differences between samples of respondents in their choices of most favoured and least favoured choices illustrations.
3) That there will be no significant differences between samples of respondents in their frequencies of yes/ no choices for a particular illustration.
4) That there will be no significant differences between samples of respondents in the frequencies of their right and wrong answers for each of two selected illustrations (**perlemoen** and **fly**).

University of Cape Town

5) That there will be no significant differences between samples of respondents in the frequencies of their "well drawn/ poorly drawn" assessments for each of the two selected illustrations of the **fly** and the **perlemoen**.

To test the hypotheses, the study used samples of 1100 disadvantaged learners (in four low socio-economic status schools), 960 advantaged learners (in eight medium socio-economic status schools), 29 high school teachers (in eight schools) and 35 primary and secondary school teachers-in-training. They responded to two kinds of questionnaires, namely a textbook-based questionnaire and an auxiliary pictorial questionnaire.

The respondents were asked to use six standard, professionally selected criteria to assess and grade 40 illustrations in the school textbook *New Nations Science Grade 7 (1999)*. The learners used basic criteria provided by expert colleagues in graphic art and design at Groote Schuur Hospital and Michealis School of Fine Art at the University of Cape Town, but expressed in simple language. The respondents were also required to indicate whether, in their view, certain illustrations were an accurate scientific representation of what the textbook artist claimed they were. Each respondent had his or her own new, free copy of the textbook to evaluate the illustrations, considered ten at a time, rated on a five point scale as either "poor", "fair", "good", "very good" or "excellent" for each of the six criteria. The analysis involved the use of qualitative and quantitative research methods.

University of Cape Town

The inter-group correlation ratings obtained between the assessments of four pairs of groups (advantaged and disadvantaged learners; high school and primary school teachers) for ten illustrations rated inclusively yielded values between 0.70 and 0.93. These high learner-to-learner and teacher-to-teacher correlations suggest that the rating exercise was taken seriously and consistently by most, if not by all of the participants. An important finding of the study was that, although there were significant differences in individual preferences and ratings among the groups, the learners appeared to be genuinely expressing how they felt about the illustrations. The learners were found to be more positive in their ratings, whilst the teachers tended to rate more conservatively than the learners, on the whole.

Of the 40 illustrations evaluated, each one assessed according to six separate criteria, only three illustrations, namely the **chicken** (textbook page 100), **days of big rain** (textbook page 145) and the **hippo** (textbook page 157) received mean ratings of less than 2.00 ("fair") on at least one of the six assessment criteria; so these will be referred back to the artist. The learners expressed problems with the **size** of 60 % of the illustrations; a dissatisfaction with the lack of **labels;** as well as their **interpretation** and **understanding** of certain illustrations such as the **perlemoen.**

Overall, the sample of disadvantaged learners expressed less satisfaction with the quality of the illustrations in the textbook than the other samples of evaluators, and their written reasons provide useful feedback to science textbook illustrators.

University of Cape Town

The illustrations which received the highest ratings on all six criteria, and which were most favoured by all the samples were the **fly**, **water cycle** and **penguins**.

University of Cape Town

ACKNOWLEDGEMENTS

- A special word of thanks is due to my supervisor, Professor Kevin Rochford, for his unreserved availability; guidance and constructive criticism; and his untiring efforts in reading through the drafts and advising and assisting to edit and sharpen my presentation.
- The National Research Foundation for granting me financial assistance.
- Ms Greg McCutcheon of McMillan Publishers (formerly Hodder and Stoughton) for the donation of the textbooks.
- Michael Wyeth of Groote Schuur Hospitals' Medical Graphic Department, for finalising the criteria used in the textbook questionnaire, as well as his evaluation of the illustrations in the textbook
- The principals who allowed me to administer the questionnaires in their schools.
- The assistance of all the teachers and the science learners in the schools who completed the questionnaires.
- Hilary, for her patience, guidance, encouragement and assistance with the data-capture process.

University of Cape Town

This research study is dedicated to my mother.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview 13

2.2. Functions, purposes and reasons for illustrations in school textbooks 13

2.2.1. Illustrations as motivators 16

2.2.2 Illustrations as enhancers of learning achievement 18

2.2.3. The development of visual literacy 21

2.2.4. Implications 22

2.3. Problems in the teaching and learning of illustrations 23

2.3.1 Introduction 23

2.3.2 Factors contributing to problems in the teaching and learning of illustrations 24

a) Problems with illustration interpretation 24

b) Problems of distraction and complexity 25

c) Problems of discernment and extraction 26

d) Perceptual problems 28

e) Spatial proficiency 28

f) Problems of science learners' ignorance of conventions 29

g) Learners' problems with graphics 29

h) Problems with usage 30

2.3.3 Implications 32

2.4 Factors influencing accurate interpretation of illustrations 33

2.4.1 Readers' culture / ethnicity 33

2.4.2. The colour of the illustrations 34

2.4.3. The size of the illustrations 35

University of Cape Town

3.4 The location and administration of the research 62

3.5 The samples in their contexts 62

3.6 The research design 64

3.7 Data collection 65

3.8 The survey research method 66

3.9 Procedures for data collection 66

3.10 Administration and outcomes of the pilot studies 68

3.11 Administration of the final version of the text-based questionnaire 71

3.12 The interviews 75

3.13 Data capture 77

3.14 Selection of statistical methods 78

3.15 Methodological limitations of the research 79

3.16 Chapter summary 80

CHAPTER 4: RESULTS AND FINDINGS

PART A: CONCURRENCE OF THE RESPONDENT EVALUATORS 85

PART B: PRESENTATION OF THE MAJOR FINDINGS 92

4.1. Overall quantitative findings 92

4.2. Qualitative results [pertaining to tables 4.5 to 4.9] 98

PART C: COMPARISONS BETWEEN THE EXPRESSED LEVELS OF SATISFACTION WITH THE TEXTBOOK ILLUSTRATIONS BY DIFFERENT SAMPLES OF RESPONDENTS 119

4.3 Overall summary of results for part C 120

4.3.1 Who are more favourably disposed towards the 120

University of Cape Town

illustrations, the disadvantaged learners or the advantaged learners

4.3.2 Who are more favourably disposed towards the illustrations, the disadvantaged learners or the teachers? 120

4.3.3 Who are more favourably disposed towards the illustrations, the advantaged learners or the teachers? 121

4.3.4 Who are more favourably disposed towards the illustrations, the high school teachers or the primary school teachers? 121

4.3.5 Who are more favourably disposed towards the illustrations, the high school teachers or the primary school teachers? 121

PART D: COMPARISONS BETWEEN THE YES/ NO RESPONSES OF THE TEXTBOOK ILLUSTRATIONS BY DIFFERENT SAMPLES OF RESPONDENTS 122

4.4. The disadvantaged science learners (N = 796) and the advantaged science learners (N = 788) with regard to the yes/ no responses 122

4.5. The high school teachers (N = 29) vs. the primary school teachers (N = 32) with regard to the yes/ no responses 126

4.6 The school teachers (N = 61) vs. the science learners (N = 1584) with regard to the yes/ no responses 128

PART E: PRESENTATION OF THE FINDINGS WITH SPECIAL REFERENCE TO THE FLY, THE PERLEMOEN, THE INSIDE OF AN EGG AND THE DEVELOPMENT STAGES OF THE CHICK. 130

4.7. Identification of the two illustrations 131

4.7.1. The disadvantaged learners (N = 270) vs. the advantaged learners (N = 160) 132

4.7.2. The Grade 8 learners (N = 212) vs. the Grade 9 learners (N = 218) 133

University of Cape Town

4.7.3. The high school teachers (N = 21) vs. the primary school teachers (N = 34) 134

4.7.4. The school teachers (N = 55) vs. the science learners (N = 430) 135

4.8. The correct identification of the drawing of the egg 136

4.8.1. Suggestions for improvements to the illustration of the egg 136

4.9. Indications whether the illustrations are well drawn or poorly drawn 136

4.9.1. The 270 disadvantaged learners vs. the 160 advantaged learners 137

4.9.2. The 212 Grade 8 learners vs. the 218 Grade 9 learners 138

4.9.3 The 21 high school teachers vs. the 34 primary school teachers 139

4.9.4 The 55 school teachers vs. the 430 learners 140

4.10 The correct labels next to the drawing numbers 141

4.10.1 The disadvantaged learners 141

4.10.2 The advantaged learners 142

4.10.3 The school teachers 143

4.11 Chapter summary 144

CHAPTER 5: DISCUSSION OF RESULTS 145

5.1 A discussion of the importance of illustrations and reasons for including them in textbooks 146

5.2 Types of illustrations 147

5.3 Problems encountered with the learning of illustrations 148

5.3.1 Diagram interpretation 148

5.3.2 Perceptual problems 150

University of Cape Town

5.3.3 Learners' problems with graphics 151

5.4 Factors which may affect accurate interpretation of illustrations 153

5.4.1 The colour of the illustration 153

5.4.2. The size of the illustrations 154

5.4.3. The labels/ information 155

5.4.4 Age 156

5.4.5 Relevance to the text 157

5.5 Discussion with regard to textbook illustrations 158

5.6 Implication of this discussion for the textbook *New Nation* Science Grade 7 (1999) 161

5.7 Chapter summary 162

CHAPTER 6: IMPLICATIONS, RECOMMENDATIONS AND CONCLUSIONS

6.1 Implications for effective teaching of illustrations in classrooms 164

6.2 Recommendations for effective teaching of illustrations in classrooms 166

6.3 Recommendations to the publishers for better understood illustrations by the learners 167

6.4 Recommendations for future research. 168

6.5 Conclusions 169

References 171

Bibliography 180

University of Cape Town

LIST OF APPENDICES

Appendix 1a: Letter for donation of textbooks

Appendix 1b: Letter of permission to do research at a school

Appendix 2a: The textbook-based questionnaire

Appendix 2b: The English version of the pictorial questionnaire

Appendix 2c: The Xhosa version of the pictorial questionnaire

Appendix 3: Tables 4.10 to 4.33: The respondents' ratings to the illustrations' specified criteria.

Appendix 4: Photocopies of some of the responses for the choice of most favoured/ least favoured illustrations and the agree/ disagree responses.

Appendix 5: The New Nation Science (1999) Textbook

Appendix 6: Examples of ratings

University of Cape Town

LIST OF TABLES

TABLE		PAGE
Table 2.1	Instructional interventions and their effects on learning from text illustrations.	44
Table 4.1	An overview/ summary description of the volunteer respondent groups; their evaluated chapters; and their evaluated illustrations	84
Table 4.2	Overall impression ratings of ten illustrations in textbook chapter 7, by 200 advantaged learners (A), 250 disadvantaged learners (D), 28 high school teachers (HST) and 35 primary school teachers (PST).	87
Table 4.3	Correlations between the values of four groups' ratings of ten common textbook illustrations (A = 200 advantaged learners; D = 250 disadvantaged learners; HST = 28 high school teachers; PST = 35 primary school teachers).	89
Table 4.4	A frequency comparison of the most favoured/ least favoured responses by the school teachers (N = 61) and the science learners (N = 450) to the illustrations in textbook chapter 7.	91
Table 4.5	A frequency comparison of the most favoured/ least favoured responses by the 190 disadvantaged (N_a) vs. 172 advantaged learners (N_e) for ten illustrations in textbook chapter 2.	93
Table 4.6	A frequency comparison of the most favoured/ least favoured responses by the 178 disadvantaged (N_b) vs. 237 advantaged learners (N_f) for ten illustrations in textbook chapter 1.	94
Table 4.7	A frequency comparison of the most favoured/ least favoured responses by the 237 disadvantaged (N_c) vs. 166 advantaged learners (N_g) for ten illustrations in textbook chapter 5.	95
Table 4.8	A frequency comparison of the most favoured/ least favoured responses by the 252 disadvantaged (N_d) vs. 200 advantaged learners (N_h) for ten illustrations in textbook chapter 7.	96

University of Cape Town

Table 4.9	A frequency comparison of the most favoured/ least favoured responses by the high school teachers (N = 29) and the primary school teachers (N = 32) for ten illustrations in textbook chapter 7.	97
Table 4.10 (a)	A summary of the results of the 190 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 1
Table 4.10 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 2
Table 4.10 (c)	A summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 3
Table 4.10 (d)	A summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 4
Table 4.11 (a)	A summary of the results of the 190 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the satisfaction of the **clearness** illustrations.	Appendix 4 pp 5
Table 4.11 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **clearness** of the illustrations.	Appendix 4 pp 6
Table 4.11 (c)	A summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **clearness** of the illustrations.	Appendix 4 pp 7
Table 4.11 (d)	A summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **clearness** of the illustrations.	Appendix 4 pp 8
Table 4.12 (a)	A summary of the results of the 189 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the satisfaction of the **colour** of the illustrations.	Appendix 4 pp 9
Table 4.12 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **colour** of the illustrations.	Appendix 4 pp 10
Table 4.12 (c)	A summary of the results of the 236 disadvantaged (Nc) vs. 164 advantaged learners (Ng) with regard to satisfaction with the **colour** of the illustrations.	Appendix 4 pp 11

University of Cape Town

Table 4.12 (d)	A summary of the results of the 251 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **colour** of the illustrations.	Appendix 4 pp 12
Table 4.13 (a)	A summary of the results of the 190 disadvantaged (Na) vs. 171 advantaged learners (Ne) with regard to the satisfaction of the **relevance to the text.**	Appendix 4 pp 13
Table 4.13 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **relevance to the text**.	Appendix 4 pp 14
Table 4.13 (c)	A summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **relevance to the text.**	Appendix 4 pp 15
Table 4.13 (d)	A summary of the results of the 251 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **relevance to the text.**	Appendix 4 pp 16
Table 4.14 (a)	A summary of the results of the 190 disadvantaged (Na) vs. 180 advantaged learners (Ne) with regard to the satisfaction of the **suitability for Africa.**	Appendix 4 pp 17
Table 4.14 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **suitability for Africa**.	Appendix 4 pp 18
Table 4.14 (c)	A summary of the results of the 230 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **suitability for Africa.**	Appendix 4 pp 19
Table 4.14 (d)	A summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **suitability for Africa.**	Appendix 4 pp 20
Table 4.15 (a)	A summary of the results of the 190 disadvantaged (Na) vs. 180 advantaged learners (Nd) with regard to the satisfaction of the **overall impression** of the illustrations.	Appendix 4 pp 21
Table 4.15 (b)	A summary of the results of the 178 disadvantaged (Nb) vs. 235 advantaged learners (Nf) with regard to satisfaction with the **overall impression** of the illustrations.	Appendix 4 pp 22

University of Cape Town

Table 4.15 (c)	A summary of the results of the 237 disadvantaged (Nc) vs. 164 advantaged learners (Ng) with regard to satisfaction with the **overall impression** of the illustrations.	Appendix 4 pp 23
Table 4.15 (d)	A summary of the results of the 251 disadvantaged (Nd) vs. 194 advantaged learners (Nh) with regard to satisfaction with the **overall impression** of the illustrations.	Appendix 4 pp 24
Table 4.16 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 25
Table 4.16 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 26
Table 4.16 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 27
Table 4.16 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 28
Table 4.17 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **clearness** of the illustrations.	Appendix 4 pp 29
Table 4.17 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **clearness** of the illustrations.	Appendix 4 pp 30
Table 4.17 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **clearness** of the illustrations.	Appendix 4 pp 31
Table 4.17 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **clearness** of the illustrations.	Appendix 4 pp 32
Table 4.18 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **colour** of the illustrations.	Appendix 4 pp 33

University of Cape Town

Table 4.18 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **colour** of the illustrations.	Appendix 4 pp 34
Table 4.18 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **colour** of the illustrations.	Appendix 4 pp 35
Table 4.18 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **colour** of the illustrations.	Appendix 4 pp 36
Table 4.19 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **relevance to the text**.	Appendix 4 pp 37
Table 4.19 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **relevance to the text**.	Appendix 4 pp 38
Table 4.19 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **relevance to the text**.	Appendix 4 pp 39
Table 4.19 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade G learners (Nr) with regard to the perception of the **relevance to the text**.	Appendix 4 pp 40
Table 4.20 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **suitability for Africa**.	Appendix 4 pp 41
Table 4.20 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **suitability for Africa**.	Appendix 4 pp 42
Table 4.20 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **suitability for Africa**.	Appendix 4 pp 43
Table 4.20 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **suitability for Africa**	Appendix 4 pp 44
Table 4.21 (a)	A summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **overall impression** of the illustrations.	Appendix 4 pp 45

University of Cape Town

Table 4.21 (b)	A summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **overall impression** of the illustrations.	Appendix 4 pp 46
Table 4.21 (c)	A summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **overall impression** of the illustrations.	Appendix 4 pp 47
Table 4.21 (d)	A summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **overall impression** of the illustrations.	Appendix 4 pp 48
Table 4.22 (a)	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HST) or primary school (PST) teachers with regard to the **size** of the illustrations.	Appendix 4 pp 49
Table 4.23	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HS) or primary school (PS) teachers with regard to **the clearness** of the illustrations.	Appendix 4 pp 51
Table 4.24	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HS) or primary school (PS) teachers with regard to the **colour** of the illustrations.	Appendix 4 pp 53
Table 4.25	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HS) or primary school (PS) teachers with regard to the **relevance to the text**.	Appendix 4 pp 55
Table 4.26	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HS) or primary school (PS) teachers with regard to the **suitability for Africa**.	Appendix 4 pp 57
Table 4.27	A summary of the results of the disadvantaged (D) or advantaged (A) vs. high school (HS) or primary school (PS) teachers with regard to the **overall impression**.	Appendix 4 pp 59
Table 4.28	A summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **size** of the illustrations.	Appendix 4 pp 61
Table 4.29	A summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of **clearness** of the illustrations.	Appendix 4 pp 62

University of Cape Town

Table 4.30	A summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **colour** of the illustrations.	Appendix 4 pp 63
Table 4.31	A summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **relevance to the text**.	Appendix 4 pp 64
Table 4.32	A summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of the **overall impression**.	Appendix 4 pp 65
Table 4.33	A summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of the **suitability for Africa**.	Appendix 4 pp 66
Table 4.34 (a)	A frequency comparison of the yes/ no responses by the 190 disadvantaged science learners (N_a), and the 172 advantaged science learners (N_e).	123
Table 4.34 (b)	A frequency comparison of the yes/ no responses by the 178 disadvantaged science learners (Nb), and the 237 advantaged science learners (Nf).	123
Table 4.34 (c)	A frequency comparison of the yes/ no responses by the 237 disadvantaged science learners (N_c), and the 166 advantaged science learners (Ng).	124
Table 4.34 (d)	A frequency comparison of the yes/ no responses by the 252 disadvantaged science learners (Nd), and the 200 advantaged science learners (Nh).	125
Table 4.35	A frequency comparison of the yes/ no responses by the high school teachers (N = 29) and the primary school teachers (N = 32).	127
Table 4.36	A frequency comparison of the yes/ no responses by the school teachers (N = 61) and the science learners (N = 1584).	129
Table 4.37	An overview/ summary description of the volunteer respondent groups for part E.	131
Table 4.38	A frequency comparison of the right/ wrong responses by the disadvantaged learners (N = 270) and the advantaged learners (N = 160) with respect to the illustrations of the fly and the perlemoen.	132

University of Cape Town

Table 4.39	A frequency comparison of the right/ wrong responses by the Grade 8 learners (N = 212) and the Grade 9 learners (N = 218) with respect to the illustrations of the **fly** and the **perlemoen.**	133
Table 4.40	A frequency comparison of the right/ wrong responses by the high school teachers (N = 21) and the primary school teachers (N = 34) with respect to the illustrations of the **fly** and the **perlemoen.**	134
Table 4.41	A frequency comparison of the right/ wrong responses by the school teachers (N = 55) and the science learners (N = 430) with respect to the illustrations of the **fly** and the **perlemoen.**	135
Table 4.42	A frequency comparison of the well drawn/ poorly drawn assessments by the disadvantaged learners (N = 270) and the advantaged learners (N = 160).	137
Table 4.43	A frequency comparison of the well drawn/ poorly drawn responses by the Grade 8 learners (N = 212) and the Grade 9 learners (N = 218).	138
Table 4.44	A frequency comparison of the well drawn/ poorly drawn responses by the High school teachers (N = 21) and the Primary school teachers (N = 34).	139
Table 4.45	A frequency comparison of the well drawn/ poorly drawn responses by the school teachers (N = 55) and the learners (N = 430).	140

University of Cape Town

LIST OF FIGURES

Page

Figure 2.1 Major variables in picture research (After Reid, 1990a) 27

University of Cape Town

LIST OF ABBREVIATIONS

A	Advantaged learner
D	Disadvantaged learner
Ed.	Editor
Eds.	Editors
et al.	and others
HST	High School Teachers
PST	Primary School Teachers
PSE	Picture Superiority Effect
PGCE	Post Graduate Certificate in Education

University of Cape Town

CHAPTER 1

INTRODUCTION

1.1 Origin and background to the study

At a workshop held in Cape Town in 2000, conference delegates were given fresh specimens of organs to handle, such as the kidney, brain and heart, as well as a supplementary collection of labelled illustrations of the same organs. The instruction given was that the various parts of these organs must be identified by pin point on the fresh specimens provided, using the auxiliary labelled illustrations as learning aids. Surprisingly few of the delegates (who happened to be mostly biology teachers) were able to identify with precision all the labelled structures in the fresh specimens. One of the outcomes of the task was the suggestion that some textbooks might supply more accurately labelled illustrations to assist the learners better.

Arising from this motivating incident, this study sets out to evaluate users' levels of satisfaction with samples of illustrations in a new South African textbook for junior school Science. It also aims to make a comparison of the evaluative and interpretive responses between groups of users and readers, e.g. between classes in advantaged and disadvantaged schools; between learners of different age groups; between learners speaking different home languages; between biology teachers and biology learners; and so on.

University of Cape Town

Many biology teachers rely heavily on their textbooks, and the introduction of new textbooks can be costly. With the introduction of the outcomes-based education system, new textbooks are being published in an attempt to service this new approach to education.

In the preamble to Curriculum 2005, it is stated that:

> " Experimental work is a defining characteristic of science and should feature prominently in science learning programmes. Wherever possible, practical work should involve active learner participation" (Department of Education, 1997: 4).

Specific outcome number 1 for the Natural Sciences states that learners must " use process skills to investigate phenomena related to the Natural Sciences" (Department of Education Policy Document, October 1997).

Grade 8 learners must, for example, observe the different layers in the soil. It is then expected of the learners to generate their own illustrations from their observations. To verify their observation, the textbook will be used as a reference. It is therefore important that an illustration in the textbook be accurate and understandable to the learners.

Although illustrations in biology textbooks are used to illustrate and explain concepts, authors and publishers may not be aware of the learners' perceptions or misperceptions of textbook illustrations until they are widely field-tested and evaluated *in situ*.

University of Cape Town

Arising from this present investigation, it is hoped to be able to make several recommendations, so that improved illustrations, better understood by the learners, can be included in future editions of the book.

1.2 Setting and purpose of the investigation

Many science teachers acknowledge that they are sometimes dependent on their textbook as a teaching and learning aid. However, science textbooks can become very boring without pictures and illustrations. Because pictorial representation can make reading more interesting, over the years science textbooks have become more pictorial, and illustrations are playing a more important role (Rowe, 1990: 19).

Teachers may make use of illustrations in their teaching to motivate learners and to improve learning. Pictures do have the potential to make a significant contribution to instructional textbooks. Research has also shown that under certain conditions illustrations are effective in enhancing learning (e.g. Bergerud, Lovitt and Horton, 1988).

Although it is widely accepted that illustrations do make learning material more attractive, they might play only a secondary role in the process of learning.

Brody (1982), cited in Peeck (1993: 227), states:

> " In addition to their traditional decorative role, pictures excite the learner, explain difficult concepts and expand the written narrative..... and, in addition to aiding in the acquisition of information, pictures can affect intellectual skills and processes."

University of Cape Town

There are many visual aids in textbooks which are included to help explain difficult concepts. However, many textbooks add colourful, decorative photographs and illustrations which might be there more for the selling of the book than for educating the learners. According to Holliday (1990: 27), "Experts moreover seem to agree that wide-spread use of fancy decorative photographs merely adds pages to science text without necessarily clarifying science concepts and processes."

Publishers of textbooks usually determine the quality and quantity of visual aids in texts. Up to a point they might also believe that an increase in the number of included visual aids will lead to an increase in the understanding of the printed text as well as reducing the readability load placed on the learners.

When textbooks are introduced, at first publishers might first try to please various interested groups such as teachers, education departments, tertiary institutions, etc. Leonard and Penick (1993: 14) stated that " Rather than develop a textbook for a specific market niche, nearly all publishers have taken a financially conservative shotgun approach. The resulting textbooks turn out to please few."

A basic question that needs to be asked is: Do the learners understand the drawings and illustrations in the same way as the teacher? Constable, Campbell and Brown (1988: 90) says that " the question of interpretation is fundamental and its neglect is a stumbling block to the synthesis of our understanding of the role of pictures in learning." If a biology teacher selects a particular drawing, a particular cognitive structure will shape

University of Cape Town

his/ her perception of the illustration. Whether a student has the same perception of the illustration as the teacher is not clear, yet this information might be important when selecting illustrations for a particular textbook. Hence the purpose of the present study.

During my preliminary investigations of the research problem, I spoke to illustrators of textbooks. What emerged was that many illustrators appeared to lack knowledge of who the readers were for whom they were illustrating. The editor, who decides what illustrations are to be included, cannot be sure that an appropriate illustration is in fact serving its intended purpose for the learner.

There may exist a gap between the intention behind the inclusion of an illustration, and the learners' lack of skills to understand, not only the purpose of the illustration, but possibly the illustration itself. According to Constable *et al* (1988), certain pictures are more difficult to understand than others. Lowe (1986), cited by Sanders (1995: 7), on the other hand suggests that the learners must not only understand what an image shows, but must also attempt to understand the illustration in the same way as the person who created it.

In our multicultural country we have a possible range of abilities among readers to interpret visuals. On the one hand there can be a well-endowed urban learner, who might be continually immersed in, and interacting with visual texts. On the other hand, a rural learner may have almost no interaction with visual texts. Therefore, in the South African

University of Cape Town

context, many black communities, especially rural communities, may not have high levels of visual literacies (Langhan, 1993: 32).

The problem of providing visual support in learning materials may be caused by the varied level of visual literacies among the learners. Thus, illustrators and commissioning editors should be given more detailed guidelines for the appropriate style and content of the illustrations for readers in different contexts.

Although an appreciation of the roles of illustrations in textbooks has increased, problems still remain. In the past many textbook critics considered illustrations as irrelevant and their role was often downplayed. Others simply overlooked the instructional function of illustrations. This problem was summed up by Duchcastel (1975), cited in Rowe (1990: 21), as "Rarely are illustrations in text ever considered as important instructional variables".

University of Cape Town

1.3 Objectives of the study and statement of the problem

It is known and accepted that a textbook is one of the prime instructional aids used by the teacher. Learners generally assume that what is in a textbook is correct, because it must have been written by an expert in that particular field.

Many biology textbooks include diagrams and illustrations to explain certain concepts. Soyibo (1994: 11) mentions that " illustrations are used in biology textbooks to help in the graphic explanation of the nature and functioning of biochemical and physical

processes as well as experimental apparatus".

Research findings with regard to the suitability/ appropriateness of pictures are extensive; for example Kearsey and Turner (1999); Soyibo (1999); Ramsey (1989); Reid (1990 a); Leonard and Penick (1993); Russell-Gebbett (1984); Constable *et al.* (1988). Much of the research literature concentrates on the textbooks' readability. There is relatively little information on the learners' levels of satisfaction, perceptions and understanding of the illustrations in biology textbooks in particular.

Therefore the aim of this research is to investigate a sample of Cape Town users' responses to 40 illustrations in their newly released 1999 New Nations Science textbook, and to investigate whether the ratings of satisfaction, perceptions, responses and preferences of the learners differ between advantaged and disadvantaged learners.

University of Cape Town

1.4 Importance of the research problem

Should it be found that significant differences occur in the evaluation, perceptions and response ratings of the illustrations in the biology textbook according to advantaged and disadvantaged learners, then a new avenue for further study may be opened up for investigating illustrations in biology textbooks.

Furthermore, the authors of biology textbooks may have to rethink their decisions with regard to some illustrations, if the purpose of these visual illustrations to assist with text explanation is found to be defective or problematic. On the other hand, publishers may

also be faced with the question: Is it financially viable to cater artistically for the diverse market of both advantaged and disadvantaged learners alike?

It seems possible that some well-drawn illustrations (on topics such as "dinosaurs" or "the size of the universe", for example) might motivate learners to aspire to science as a career. On the other hand, badly drawn illustrations in a textbook may cause learners to become less interested in the science, aggravating the shortage of learners choosing the science as a career.

1.5 Questions to be answered by this study

In terms of the six criteria professionally recommended and adopted for measuring 1600 respondents' perceptions of each illustration:

1. Do disadvantaged and advantaged learners **respond** to illustrations in the biology textbook in the same way?

2. Is there a difference in the **ratings** of selected illustrations in the biology textbook by high school primary school teachers?
3. Do the learners tend to respond to the selected illustrations in the same manner as their teachers?
4. Is **grade level** a significant variable in the visual perception of the illustrations, i.e. will the younger learners respond to the illustrations in the same way as older learners?

In pursuance of these questions, the following hypotheses were posited for testing.

University of Cape Town

1.6 Hypotheses

The comparative study will investigate five hypotheses with respect to the clearness, size, completeness, quality of colour, relevance to text, suitability to Africa and overall impression of 40 textbook pictures as perceived and rated by (a) advantaged and disadvantaged learners; (b) male and female learners; (c) high school and primary school teachers; (d) Grade 8 and Grade 9 and (e) teachers' and learners' as respondents. Details of these multi-faceted hypotheses will be discussed in chapter 4.

1.7 Definitions of terms

1. Illustration- this term is used in its broadest sense, namely that of a non-prose device. It includes artwork of all types namely graphs, illustrations, line drawings, pictures and photographs.

2. Perception- this is defined by Stern and Robinson (1994) as " the gathering of information through our senses and the organizing of that information in order to create meaning" (Moore and Dwyer, 1994: 32). For the purpose of this research, perception will be based on a variety of factors including experience and present feeling of satisfaction or dissatisfaction with particular illustrations.

3. For this thesis, "advantaged" or "disadvantaged" learners are classified according to the magnitude of their annual school fee levy. If the annual high school fee is less than R120, then those learners are classified as "disadvantaged."

4. Visual literacy is the ability of the learners to "read" pictures (Goldsmith, 1984; Kress and van Leeuwen, 1996). Platt (1975), cited in Seels (1994: 103), defined visual literacy

University of Cape Town

as "people having the ability both to understand and to express themselves in terms of visual material, to enable them to relate visual images to meanings beyond the images themselves."

1.8 Delineating the study

1. Data will be collected from schools in Cape Town only.
2. Only Grade 9 and grade 8 learners will be involved.
3. Only one textbook, viz. New Nation Science Grade 7: Opie, Enderstein and Amosun (1999) will be used.

1.9 Assumptions of the study

This investigation assumes

1. That the learners will be interested in the evaluation exercise, will be in a positive mood and will like their teacher who is conducting the data collection.
2. That the Xhosa–speaking learners will be able to answer the straightforward questions equally as well as the other learners.
3. That the learners will be pleased to handle a fresh new book and will feel honoured and privileged to be selected and invited to review it at the time of its release.

University of Cape Town

1.10 Research approach

Questionnaires will be used to collect both qualitative and quantitative information with regard to the respondents' perception of illustrations.

Copies of the textbook New Nation Science Grade 7 (1999), as well as the data-gathering instruments, will be issued to grade 8 and 9 learners. After a series of pilot trials to develop a consistent, comprehensive data-gathering instrument, response data from 1600 high school learners will be collected through heads of biology departments.

In an auxiliary study to evaluate in-depth content, four illustrations will be selected from the textbook. A second, more specific data-gathering instrument will be issued to a sub-sample of 200 Grade 8 and 9 learners for the auxiliary study.

Chi-square tests, t-tests and correlations will be used to analyse and compare the patterns of the quantitative responses in the data, after checking for normality and comparable variances in the distribution of the patterns in the response data. The qualitative findings will be presented as a condensed list summarising more than 300 000 descriptive commentaries on 57 illustrations by the 1655 respondents.

The respondents' suggestions, explanations and reasons offered to justify for the qualitative findings will serve two purposes. Firstly, the list will be used as evidence to support and strengthen, or to modify current theories of assessing textbook illustrations. Secondly, the common list of emergent suggestions will be forwarded to the editors of the evaluated science textbook.

University of Cape Town

1.11 Organisation of the remainder of the dissertation

Chapter 2 deals with the review of the literature, and elaborates on the theoretical background of the problem.

Chapter 3 describes the research methodology in detail.

Chapter 4 consists of the presentation of the qualitative results and a summary of the qualitative results.

Chapter 5 discusses both the quantitative research findings and the qualitative results.

Chapter 6 formulates recommendations for further research and presents the implications and conclusions to the study.

1.12 Chapter summary

In this introductory chapter the research problem has been formulated and its origin, context, purposes, background and significance stated.

The aim, as well as the objectives of the research, have been given, together with reasons for conducting the study. The limitations of the investigation, the hypotheses and definitions have been clarified.

The research methods have been introduced and the intended data-gathering procedures outlined; the respondent samples and data-gathering instruments have also been described as well as the proposed methods of analysis of the data.

The next chapter develops the theoretical framework of this research in detail; and it suggests how this present research will make its own contribution to filling some gaps that may currently exist, in the published science education literature, with regard to the perception of illustrations in biology textbooks.

University of Cape Town

CHAPTER 2

LITERATURE REVIEW

University of Cape Town

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, the review first focuses attention on literature pertaining to the **reasons** for using illustrations. Secondly, an analysis is made of the **problems** that are encountered in the teaching and learning of drawings and illustrations in school textbooks. Thirdly, factors which affect the accurate **interpretation** of illustrations are described. Fourthly, strategies used to **teach** illustrations and illustrations are described. Then a review is made of research findings with specific reference to the teaching and learning of **illustrations in science and biology**. After each section the chapter deduces and presents possible implications of this literature review for current school science textbooks. Finally, the chapter points out some gaps existing in the published literature, and how the present study will help to **complete some of these gaps** in the existing research.

University of Cape Town

2.2 Functions, purposes and reasons for illustrations in school textbooks

Most biology textbooks provide illustrations, which vary in quality and quantity. Questions that might be asked are: "Why are illustrations included? "; " What is the purpose of a particular illustration?"; "Is there a relationship between the kind of illustration and its instructional value?"

These questions can be answered by first stating the category into which the illustration falls. Duchcastel (1980), cited in Rowe (1990: 30), divided the functions of illustrations into three broad categories, namely **attentional, retentional** and **explicative.** The attentional illustration is one whose main purpose is to keep the reader interested in the text. The retentional illustration provides information that a verbal text has difficulty portraying. The explicative illustration assists comprehension by clarifying a point in the text visually.

Levin, Anglin and Carney (1987: 53), on the other hand, divided the functions of illustrations into five broad categories, namely **decorative, representational, organizational, interpretational** and **transformational.** The decorative function is associated with text-irrelevant pictures that are selected to help the reader **enjoy** the textbook and make it more attractive. The representation function refers to illustrations that tell exactly the same story as words, and which subsequently overlap with the text. These illustrations help the reader to **visualize**, for example, a particular event. The organization function refers to pictures which provide an organizational framework for a text and give a greater understanding to it.

University of Cape Town

These illustrations can help the reader to organize information in a **coherent** structure. The interpretation function occurs when pictures clarify passages that are difficult to **understand** and which elucidate abstract concepts within passages. The transformation function refers to pictures that are designed to impact on the learners' memory directly. These illustrations help the reader to **remember** key information in a text. The inclusion of representational, organizational and interpretational types of illustrations in textbooks

supplements the presented text, and therefore produces a positive effect on the learners' memories.

Doblin(1980), cited in Rowe (1990: 30), provides a comprehensive structure for classifying the use of visuals, which includes **visual nominal, visual noumenal and visual phenomenal.** Visual nominal illustrations are visual words such as trademarks and road signs. Visual noumenal illustrations are charts and graphs. Visual phenomenal illustrations include illustrations, photography and model making.

According to Twyman (1985), cited in Rowe (1990:31),

> " There are eight variable factors that are part of graphic language: *purpose, information content, configuration, mode, means of production, resources, users, and circumstances of use*. If a graphic is to work well, all of these variables must be considered."

Constable (1988: 90) lists three important functions of a picture: **getting** people's **attention**, helping them to **remember details** and **helping in explanation.**

Several researchers have therefore outlined the various uses and roles of illustrations. Although differences exist in the functional classifications, all include "the **attentional role** that illustrations play in appealing to the eye, **motivating the learner** to pick up, browse through and read the text, in making reading more enjoyable and bringing excitement to the topic" (Evans, Watson and Willows, 1987: 90).

The appropriate attentional and motivational aspects of illustrations are important for teachers. Sless (1981), cited in Evans *et al* (1987: 92), has aptly written:

University of Cape Town

> " Despite the endless production of pictures in our culture, most of them are used in this superficial 'attention' role. It is therefore likely that unless the context in which they are to be used offers sufficient guidance to their use, most learners will presume that they have an attentional role and therefore treat them as incidentally relevant to learning."

Many teachers use illustrations to clarify and explain what the text is saying. The illustrations are also regarded as a second medium with which to communicate and to represent selected concepts. This is especially true in the case of science and technical books.

In the case of novice readers, the rationale for illustrations is quite different.

According to Evans *et al* (1987: 91),

> " Illustrations are almost as important as content in early learning. They help the child to read the story by looking at the pictures without spoiling the story. Illustrations play an even more important role in communicating ideas to children (than text)".

There are three main reasons for illustrations in textbooks, and these are now explained.

2.2.1 Illustrations as motivators

Illustrations are included in biology textbooks as aids to learning. Smith (1960), cited in Ramsey (1989: 46), noted that the rationale for the inclusion of illustrations was the ability of those illustrations " to perpetually motivate the reader – to attract him to pick up the book, to explore it, and, above all, to develop a high feeling of expectancy in turning a page".

Kingman (1968), cited in Ramsey (1989: 46), also supported this and further stated:

University of Cape Town

> " Does the illustration compel one to pick up the book, hold it, see more? Does the illustration invite the next step, reading the story? A child is quick to say, 'But I don't like the pictures,' and then refuse to read the book".

According to Donald (1981: 2), illustrations have a motivational role by enlivening the presentation of a text that, were it not illustrated, would appear dull to young readers. The factors which might have a bearing on this role could be the size, frequency and layout of the illustrations, colour, etc.

Reid (1984: 29) showed that there is substantial research in psychology which suggests that improved learning takes place when pictures are available as stimuli to the learner, and this phenomenon has generally come to be known as the 'picture superiority effect' (PSE). According to Sanders (1995:7), the picture superiority effect is unlikely to occur if learners are unable to interpret what the illustrators' conventions or cues represent.

Reid (1990 b: 254) concluded that his findings replicated those found in other fields, namely that pictures do not have a general motivating effect on learning, and that only pictures containing specific information already in the text are involved in the so called picture superiority effect.

Constable, Campbell and Brown, (1988: 100) pointed out that certain pictures are more difficult to interpret than others, because they use more pictorial conventions (artists' depth cues), and that the latter is often not understood by the viewer. According to Russell-Gebbett (1984: 220), a lack of spatial skills can also be an obstacle in interpreting illustrations.

University of Cape Town

2.2.2 Illustrations as enhancers of learning achievement

Many researchers have agreed that illustrations do play a valuable role in teaching, but some reservations have been expressed as to their value (Samuels, 1970; Lippman and Shanahan, 1973; Concannon, 1975, as cited in Constable *et al* 1988: 89).

Brody (1982), cited in Peeck(1993: 227), indicated that " in addition to their traditional decorative role, pictures can excite the learner, explain difficult concepts and expand the narrative. Furthermore, there are indications that, in addition to aiding in the acquisition of information, pictures can affect intellectual skill and processes."

Research has shown that the retention of text content is improved by illustrations. Various explanations have been offered by research to account for the facilitative retention effects of illustrations. According to Peeck (1993: 228):

> " Pictures might motivate the learner to study the accompanying text; they might focus attention or induce more elaborate processing of text information covered in illustrations; they might help to clarify and interpret text content that is hard to comprehend, or they might help to establish nonverbal codes alongside verbal ones and, as a result, increase retrieval potential for the illustrated content."

Kearsey and Turner (1999: 88) indicated that it had been shown that figures included in textbooks help in the explanation and understanding of the written text. Reid (1990 a) also agreed that learning from text in biology is enhanced by the presence of pictures.

University of Cape Town

However, Holliday (1975), cited in Kearsey and Turner (1999: 88) felt pictures do not have a great influence in the understanding of the text. In a study of the investigation of the understanding of biological texts by biological learners aged 14 to 16 years, Dwyer (1972), cited in Kearsey and Turner (1999: 88), came to the conclusion that the effectiveness of pictures depended on the educational objectives and method of presentation, and concluded that the **gender** of the viewer as well as the **size** of the pictures, had **little** effect on learning, and that **colour** had a variable effect.

In their study of the effect on learning of pictures, Reid and Beveridge (1986) and Reid (1990 b), also came to the conclusion that the mere presence of pictures does not have a motivating effect, and only those pictures which contained information which are included in the text enhanced learning.

According to Constable *et al* (1988: 89):

> " The use of pictures as components of learning and teaching can be justified on two grounds. Firstly, that illustrations assist learning and, secondly, that learning to use illustrations is a valuable educational aim in itself. Furthermore, it can be argued that learning to use illustrations is part of essential subject knowledge."

Numerous researchers have investigated the use of pictures in education, and to what degree the pupils can recognise the objects depicted as illustrations. It has been found that the mere naming or matching of the object does not necessarily mean an understanding of the object depicted, but an understanding of the relationship of the parts in the whole picture is needed.

University of Cape Town

According to Levie and Lentz, 1982, cited in Reid and Beveridge (1986: 294), research has indicated that, under certain conditions, pictures could assist in the recall of information from text, but this facilitatory effect did not occur consistently. Reid and Beveridge (1986: 294) showed under which conditions pictures did assist with text processing. According to them there existed a relationship between the **difficulty** of the text and the **capacity of the pictures to assist** the learners.

Holliday (1976), cited in Rowe (1990: 26), "showed that illustrations could significantly improve middle-school learners' comprehension of physical concepts such as density, pressure and Archimedes' Principle." Reid and Beveridge (1986: 294) also concluded, " pictures enhance comprehension in good readers but not in poor readers." However, this finding is contradicted by other studies (Levie and Lentz, 1982; Koran and Koran, 1980 as cited in Kearsey and Turner, 1999: 88).

In a study to understand the effect that pictures have on learning, Reid, Briggs, Beveridge, (1983: 327) found that when pictures were used, the learners remembered the work better than when the text alone was used. However, in a later study, Reid and Beveridge (1986: 294) unexpectedly found that pictures do not have a motivational effect on learning and that, whilst the high ability learners benefited from the illustrated text, the lower ability learners were confused by it.

University of Cape Town

2.2.3 The development of visual literacy

Goldsmith (1984: 27) and Kress and Van Leeuwen (1996: 11) describe visual literacy as the ability of the learners to 'read' pictures. Visual literacy is an important factor in the successful use of figures to support learning. Levie (1987) showed that instruction can help in the development of visual literacy.

According to Piaget's stages of development, a child needs to have had experience with concrete materials and to have translated these experiences into representational form before abstract thinking is possible (Hortin, 1994: 11). " Within this framework, visual material becomes a necessary component for helping the inexperienced learner bridge the gap between concrete experiences and symbolic representations of real-world phenomena " (Miller and Burton, 1994: 72). Linked to this, Paivio's dual-code model distinguishes between the codes used for visual and verbal information, stating that

> " the two types of information ... are encoded by separate subsystems, one specialised for visual images and the other specialised for verbal language. Although the subsystems can function independently, they are interconnected, so that a concept represented as an image in the visual system can also be converted to a verbal label in the other system, or vice versa " (Miller and Burton, 1994: 73).

Much of the philosophy that has had an impact on the development of visual literacy theory is concerned with metaphor. Turbayne (1970: 13) extended the definition of metaphor to include the work of 'artists who "speak" in paint to "speak" in metaphor.

University of Cape Town

Thus, visuals are included in order to aid and encourage the retention of both visual and verbal knowledge through visual means. There are, however far broader applications for visuals. It is possible for the visual text to be used as the primary textual material, and not simply the support for the verbal text. That is, a visual text can be used as the starting point for the discourse.

2.2.4 Implications

From a discussion of the three main reasons for illustrations in textbooks, the implications for this dissertation are that, because some learners lack opportunities to interact with pictures they may lack the ability to make sense of illustrations that are supposed to aid learning. To assist learners with this difficulty, we need to know how it is possible to teach visual literacy for particular drawings and illustrations, so that their perceptual skills can be improved. Also, we need to study how the information contained in the visuals is made accessible to learners, as well as how to improve critical interaction skills with visuals.

University of Cape Town

Dwyer (1994: 386) identifies a "lack of guidelines related to the design and use of visualization to optimize student learning." According to Dwyer, research is needed which will focus on the cause and effect relationships between different kinds of visuals and their planned outcomes, "which will provide guidelines for the effective use of different types of visuals, which in turn would enable educators to design and/ or select specific kinds of visualization "(page 385).

2.3 Problems in the teaching and learning of illustrations

2.3.1 Introduction

Often learners are not aware of the functional differences between the different kinds of visual aids. The teacher must be aware of the visual literacy base of the learners in a class because

> " Learners see some illustrations the same way some Americans watch an English cricket game: they know something is going on, but they do not know what it is" (Rowe, 1990: 36).

The first section of this literature review has emphasised the positive effects that pictures have on instructional texts. However, a question that can be asked is: Are the significant contributions that pictures have in everyday educational practice actually achieved? Weideman (1989), cited in Peeck (1993: 228), has a pessimistic view of the benefits of pictures in educational texts and concludes that:

> "Learners will often deal with illustrations in a superficial or otherwise inadequate way, with the result that 'good pictures fail' in achieving any contribution to the instructional text."

The standing of text illustrations in the educational process therefore appears to be contradictory. On the one hand there is acknowledgement of the positive role of illustrations, whilst on the other hand there is plenty of reason to regard their effects with realistic pessimism.

In this section of the thesis I therefore wish to highlight some of the problems which contribute to the pessimistic views of illustrations.

University of Cape Town

2.3.2 Factors contributing to problems in the teaching and learning of illustrations

Illustrations are an important and integral part of many aspects in the teaching of the science, especially biology. Text illustrations can have an important effect on learners' learning. Frequently in biology, structure is more easily explained by using visual aids such as illustrations.

a) Problems with illustration interpretation

Learning is not necessarily enhanced by the presence of illustrations, for example, if the learners are unable to interpret what the illustrations' conventions or cues represent. According to Constable *et al.* (1988: 90) learners struggle to interpret the illustrations in the way they were intended by the artist. The interpretation of textbook illustrations poses problems for biology learners at school level. Wood-Robinson (1984), cited in Sanders (1995: 7), concluded that:

> " Many teachers and textbook writers make unjustified assumptions about their learners' ability to relate plane sections to the solids from which they were taken."

University of Cape Town

In an analysis of diagnostic tests of first year university learners, Sanders (1995: 8) found that "there were widespread problems regarding the interpretation of illustrations of familiar and unfamiliar biological sections". According to Sanders

> " It was possible that even some of the high achievers in biology were rote-learning illustrations (and labels) of biological sections. Furthermore, many South African biology teachers may not be fully aware of the difficulties experienced by learners in their classes" (page 8).

b) Problems of distraction and complexity

According to Evans *et al.* (1987), teachers view illustrations as helpful in both conveying meaning and motivating children in learning. However, they can be diversionary at times by being too striking and too engaging. For primary school learners the illustrations become distractors. The learners may focus on the drawing rather than to listen, read, think and use their own imagination when following a lesson. Evans *et al.* (1987: 93) concluded, " At junior levels the most common criticism of illustrations was that they were sometimes too complex, busy, difficult and cluttered for the learners to apprehend."

Pictures can also divert children's attention from the printed word. In a study comparing the performance between good readers and poor readers, Willows, Rusted and Colheart, cited in Wu and Salmon (1993: 145), found that poor readers were more susceptible to the distraction of the pictorial information. This can be attributed to the fact that poor readers relied more on the pictures to elicit the correct response. Harzem *et al*, cited in Wu and Salmon (1993: 145), also came to the same conclusion, namely that any extraneous stimulus might have a distracting effect. This is emphasised by Osborne, Jones and Stein (1985), cited in Rowe (1990: 35), who stated:

> " Our observation is that graphics in texts are almost always attractive: however, we suspect that they may not always be functional and that they occasionally overwhelm and distract from the text."

University of Cape Town

c) Problems of discernment and extraction

Many illustrations used in school settings have merely an illustrative role and only serve to depict certain characteristics. However, science teachers may be unaware that the learners might not know how to use the illustrations effectively, nor do they necessarily know what features are important in the illustrations. Learning from text and illustrations may increase memory load, which may result that the intended goal, which is for the learners to develop a deeper understanding, is often not met (Gobert and Clement, 1999: 40).

According to Reid (1990(a): 161), the picture superiority effect, "whereby pictures are deemed to enhance learning from text ", is based on two assumptions: firstly that the picture is an accurate representation of the concept illustrated; and secondly, that the viewer is able to extract from the picture the information which was intended by the artist. However, the interpretation of pictorial information can pose a problem to learners.

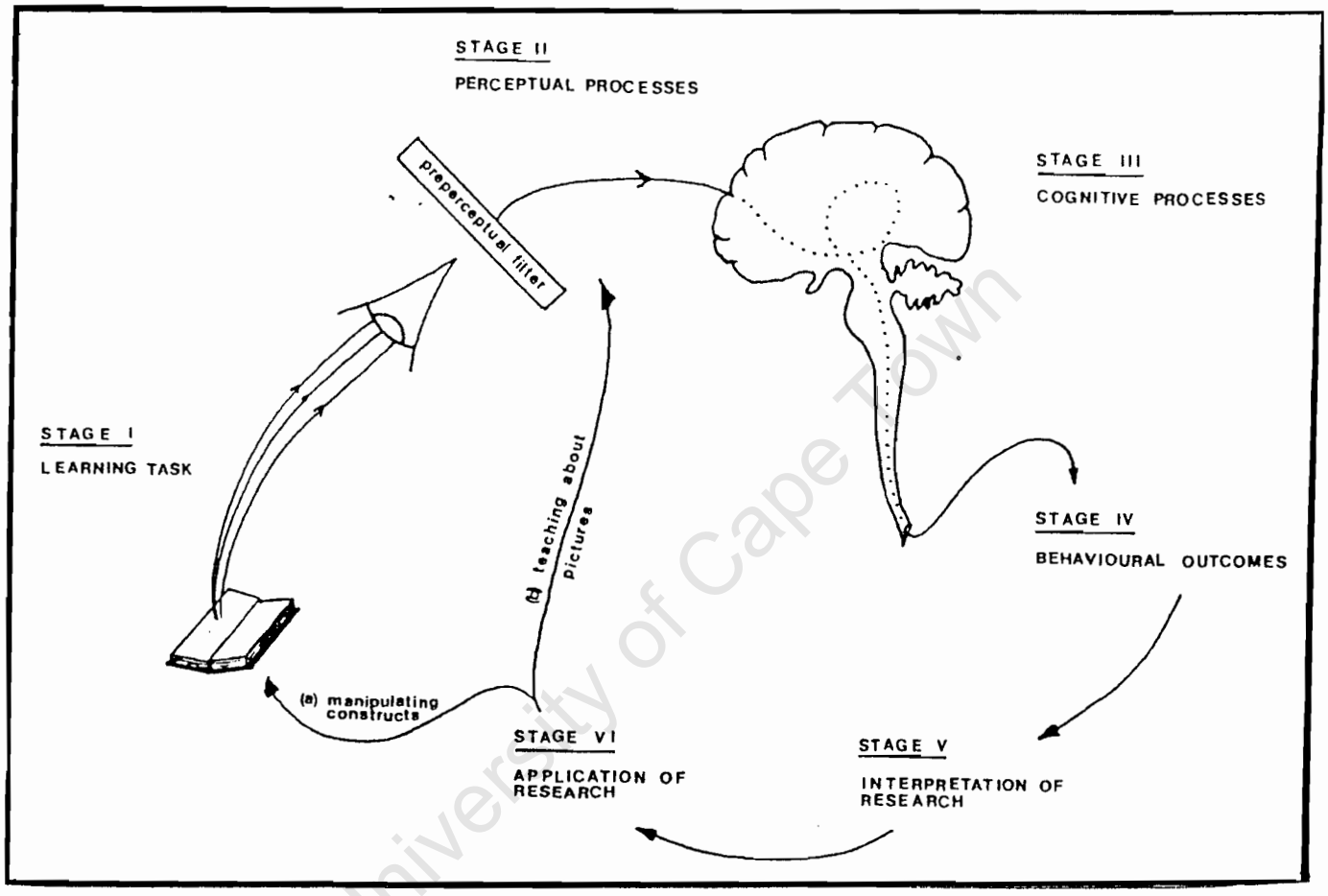
Six problem areas, (as presented in figure 2.1, on page 27), were identified by Reid (1990(a): 162). The identification of these variables is important. For the purpose of this thesis, however, only the first two variables are pertinent. They have been summarized by Reid (1990 (a): 161) as follows:

Stage 1: Represents those variables residing within the picture and text which contribute to accurate picture perception by learners.

University of Cape Town

Stage 2: Reminds us that what the learner sees in a picture is not always what the artist intends he should see.

Figure 2.1 Major variables in picture research (After Reid, 1990 (a): 162).



University of Cape Town

Reid (1990(a): 161) points out that factors which exert control over the information that the learner extracts from the picture depend on two parameters: those residing within the picture itself (such as *figure-ground differentiation, colour*, the *arrangement of the component parts* and the *depth of the field*), and those within the learner (such as *age*,

gender, *culture*, etc.). According to Reid, the within-picture variables can be manipulated to reinforce the intended message.

d) Perceptual problems

In a study of 144 eleven-year-old British learners, Constable *et al* (1988: 100) found that the learners struggled to interpret illustrations in the way meant by the artist, a perceptual problem. According to Constable " certain pictures are more difficult to interpret than others because they use more pictorial conventions (artist depth cues), and these are often not understood by the viewer". Lowe (1986), cited by Sanders (1995: 7), concluded that it is important not only to comprehend what the image showed, but also to understand it in the way the person who created it.

e) Spatial proficiency

Sanders (1995: 7) pointed out that the interpretation of illustrations may extend beyond mere perceptual difficulties. Russell-Gebbett (1984: 221) suggested that a lack of spatial skills in biology might be an obstacle. Furthermore, she pointed out that " some of the difficulties certainly seemed related to differential understanding of sectioning and the ability to abstract sectional shapes."

A similar problem was found by Wood-Robinson (1984), cited in Sanders (1995: 7). It was found that learners struggled to visualize and to draw sections through a line

University of Cape Town

illustration, or to identify correctly which of several provided shapes represent a section through the whole structure.

f) Problems of science learners' ignorance of conventions

Another problem is that there needs to be an increased awareness by science teachers of the difficulties that certain illustrations may pose for learners. According to Constable *et al.* (1988: 100):

> " If an illustration is tended to support the introduction of new material, then this will only be effective as long as the learners have sufficient understanding of whatever conventions are used in the illustration. If a learner does not understand the conventions, he may use a dimly understood view of what the object may be, to decipher the conventions."

g) Learners' problems with graphics (illustrations and pictures)

According to Gerber, Boulton-Lewis and Bruce, (1995: 79), learners encounter problems when using graphics. Gerber demonstrated that learners, throughout the formal years of schooling, experienced a wide range of difficulties understanding graphics, and that those conceptual difficulties, together with a wide range of personal factors, contributed to reduce the effectiveness of the learner to achieve meaning from these graphics (page 79).

Although graphics are used to make learning material more attractive, they tend to play only a secondary part in the process of learning and instruction, due to the literate bias of the educational system. Schnotz (1993: 151) noted a similar uncertainty with regards to the importance of graphics by the learners, and stated that:

University of Cape Town

> " On the one hand they prefer instructional material with illustrations and graphics, whilst on the other hand they frequently consider visualization to be a relatively unpretentious form of representation, and accordingly pay little attention to the graphics included in the text".

Weidenmann (1989), Salamon (1984) and Mokros and Tinkler (1987), cited in Schnotz (1993: 151), furthermore stated that " learners very often do not know how to process the presented graphics, apply inadequate processing strategies, or are not able to adequately interrelate graphic information and text information". For Schnotz the understanding of graphics goes beyond a mere perceptual analysis, " but also includes a conceptual analysis whereby the visual stimulus configuration is mapped onto certain semantic structure" (page 151). However, it is not clear what the difference is between a superficial and a deep understanding of graphics in texts, as well as how the learners integrate verbal and pictorial information.

University of Cape Town

h) Problems with usage

Sometimes well-designed instructional illustrations can be used poorly by learners, which usually stems from inappropriate processing. According to Rowe (1993: 34), the reasons for not processing the illustrations properly include the following:

Firstly, a lack of effort (that is, under-rating the demand of illustration processing). According to Rowe " illustrations need to be explored in a detailed and systematic manner so that no key pieces of information are overlooked" (page 34). Therefore learners must not approach instructional illustrations in the same informal manner as everyday pictures, otherwise the illustrations will not be processed appropriately.

Secondly, Rowe talks about misplaced effort, whereby illustrations are processed in such a way that the effort may not lead to the result anticipated by the artist, and it includes the following:

a) The learners may memorize the illustrations by using a rote-learning approach. This is unlikely to promote an understanding of the subject matter that the illustration was meant to represent.

b) The learners are unable to initiate a productive strategy for exploring the illustration, and do not know how to work systematically through the illustration.

c) Learners do not realize that the illustrations are transformed versions of the situations they represent, and that an illustration may have little resemblance to the natural state of the subject matter.

d) Learners may focus on only one level of meaning of a illustration, whilst ignoring other possibilities. To understand the illustration, the learner must have a multilevel approach to processing.

e) Many learners may fail to pick up processing cues, such as arrows, labels and captions. If the learner does not use the cues in the intended manner, much of the meaning of the illustration will be lost.

f) Learners may give too little attention to the relations depicted within the illustration (internal relations). The illustration may not serve its intended purpose if the learner does not seek out the internal relations and convert them into real world situations.

University of Cape Town

g) The learners may also fail to relate the illustration to the larger world (external relations). The learners may not realize that they can make use of related background knowledge, which will help in the understanding of the illustration.

Rowe (1993: 34)

2.3.3 Implications

Illustrations vary greatly in both the types of graphic elements from which they are comprised as well as the conventions that are involved in assembling these elements. Some learners will not know nearly as much about how to use illustrations and how they should be processed. Some learners will even say that they ignore the pictures when reading a science textbook because they find them difficult to understand.

To make effective use of an illustration, the viewer needs to be able to recognize the graphic entities, which make up the picture. The graphic material that makes up an illustration needs to be approached and processed very differently from everyday pictures. With everyday pictures, little more than an informal glance would be sufficient to process their content. However, textbook illustrations need to be more deeply processed before they can perform their intended instructional function properly and completely.

Teachers should become more aware of the problems learners encounter when processing illustrations. Deeper processing of the structure and content of a picture

University of Cape Town

can be obtained by mental manipulations of the material comprising the illustration. In this manner the learner can be helped to process an illustration more effectively. This will be discussed in more detail in a subsequent part of this chapter.

2.4 Factors influencing accurate interpretation of illustrations

There are at least five factors which influence the accurate interpretation of illustrations:

2.4.1 Readers' culture / ethnicity

The assumption that a picture is merely something that can simply be understood by anyone who can see, has been countered by Langhan (1993: 31) who quotes Fugelsang's (1978) report:

> "In social environments with no pictorial tradition or very few pictorial representations, the informal process of learning to read pictures simply does not occur. It should therefore be recognized that people's ability to read pictures is correlated with the amount of pictorial stimulation to which they have been exposed in their social environment".

In the South African context, many black communities do not have high levels of visual literacy. Langhan (1993: 32) concluded that textbooks written and illustrated for white schools were not likely to be suitable for all black learners in South Africa, as far as illustrations and other visual support were concerned. This may be because they lack the prior knowledge and experience or because they may not have been exposed to visual material from an early age.

University of Cape Town

According to Kearsey and Turner (1999: 87), some British classrooms include pupils who identify with an ethnic minority culture and " these learners might have difficulty in interpreting figures which are intended to create familiar contexts for the scientific material presented, or which are intended to present attractive role models." They suggest that photographs should be used in place of illustrations and cartoons, because photographs are explicit and portray a real, rather than a created image.

The conclusions of Kearsey and Turner correspond with the findings of Deregowski (1978), cited in Reid (1990 a: 169), who is one of the prolific writers on the effect of cultural background on picture perception, and who demonstrated that picture perception of unsophisticated Bushmen children is more accurate than that of urban blacks and whites at that time.

University of Cape Town

2.4.2 The colour of the illustrations

A number of studies which have investigated childrens' preferences for works of art have noted the importance of colour in determining choices. Colour has an important role to play in attracting attention (Allington, 1976 ; Carter, 1982 ; Rutherford *et al* , 1979), cited in Reid (1990 a: 167). It has been shown by Reid (1990 a: 167) that, although colour increases the total number of observations, it does not necessarily increase the quality of those observations.

Evidence suggested that the children were possibly sometimes distracted from the scientifically more important features of **shape**, **size** and **texture**, by the presence of

colour.

In their study of childrens' preferences for colour combinations, Reid and Wicks (1988: 350) concluded that certain colour combinations are more effective in attracting attention than others. Machotta (1966), cited in O'Hare and Cook (1983: 269), found colour to be the most frequently mentioned justification for a particular choice by children from age six upwards. Rump and Southgate (1967), cited in O'Hare and Cook (1983: 269), found similar tendencies in a study with seven year olds. O'Hare and Cook (1983: 277) came to the conclusion that " although children work extensively with colour from an early age, it is only during the pre-adolescent years that they begin to appreciate how it can be organised in order to achieve different effects."

University of Cape Town

2.4.3 The size of the illustrations

A question that can be asked is: Does the size of the illustrations make a difference to understanding the text better ? Illustrations in textbooks designed for early grades are usually large. Child development research shows that there is **no need** for an **increase** in the **size** of the illustrations.

As a rule, younger children have no problem understanding the kind of illustrations used in science texts designed for older readers.

In his investigation of the understanding of biological text by pupils aged 14 – 16

years, Dwyer (1972), cited in Kearsey and Turner (1999: 88), found that the effectiveness of pictures depended on the educational objectives and that the **size** of the pictures **had little effect** on the learning. The important factor found was that visuals must be shown in the correct proportion to one another (Holliday, 1990: 28).

2.4.4 Readers' gender

An appreciable body of research exists which documents gender differences in achievement in mathematics and science. Either males significantly outperform females, or vice versa, in particular achievement tests (Comber and Keeves, 1973 ; Forrest, 1992), cited in Soyibo (1999: 75).

Initial investigations of sex differences in science achievement by Keeves (1973), cited in Young and Fraser (1994: 857), suggested that the girls tended to perform consistently less well (but not always) than the boys in mathematics and science. Kelly (1978), cited in Young and Fraser (1994: 857), also found that the girls in his particular studies had a less favourable attitude toward science than boys.

Some studies have reported no gender achievement differences in biology tests (Okeke and Ochuba, 1986), cited in Soyibo (1999: 75). However, in a study of gender differences of Australian learners, Young and Fraser (1994: 857) reported significant differences in the biology and physics achievements of 14- and 17-year-old learners in favour of the boys. This difference did not exist among the 10 year-old and 17 year-old biology learners.

University of Cape Town

Keeves and Kotte (1996), cited in Soyibo (1999: 75), reviewed sex differences in mean science achievement scores in ten countries and concluded that clear differences in science achievement occurred between 10 year-old boys and 10 year-old girls. These differences widened during the years of high school; and were greater in the physical sciences than in biology.

Soyibo (1999: 75) concluded:

> " In many of the research studies, the magnitude of the gender differences is low. This means that, in reality, the differences are not often markedly substantial. Although they are 'statistically' significant, they are not necessarily educationally significant".

Therefore, many surveys revealed the occurrence of sex differences in average level of achievement in science, irrespective of science content, with boys usually outperforming girls. However, according to Reid (1990 b), sex differences play only a minor role in variations in picture perception.

University of Cape Town

2.4.5 The readers' age

Goldstein and Underwood (1981), cited in Donald (1983: 176), concluded that the younger and less competent the reader, the greater will be the influence of illustrations. Donald (1983: 176) did not agree with this conclusion and stated:

> "... readers would become progressively independent of illustrations as they develop their ability to utilise the linguistic constraints in the text itself as a more reliable basis for contextual prediction and confirmation."

can be asked is: How can we teach learners to interpret pictorial information and benefit more from graphics in texts?

Before this question can be answered, an account of the development of pictorial information processing by children must be considered. Binet, cited in Peeck (1987: 133), distinguished three stages of picture-interpretation by children. According to Binet, when children are presented with a picture of a scene or event, a child at the first stage will only name the number of persons or objects in the picture. During the second stage a more detailed description can be given. Only in the final stage are children capable of a more complete and correct interpretation of the picture.

Another aspect, which must be considered, is the way that children approach and understand pictures. The main problem is that children tend to treat an illustration as an isolated item, and do not understand it within a context (e.g. making use of the caption, reading the accompanying text, looking at other pictures), Peeck (1987: 134).

For the learners to gain a beneficial effect from pictures, the mere calling attention to an illustration may not be sufficient. To achieve adequate attention, the learners must be obliged to study the illustrations in a text. Research has shown that many learners are capable of processing illustrations adequately when they are simply told to do so. However, this may not be true in the case of younger children.

University of Cape Town

Children's interpretation strategies are inadequate when studying illustrations. Therefore they have to be taught how to relate to pictures in a more productive way, so that the widely reported beneficial effects of illustrations can be achieved. Illustrations should not be seen as adjuncts to the predominant text, but as sources of information in their own right. However, the information that the illustrations convey needs to be extracted adequately.

Ways of aiding learners to profit from the presence of illustrations could be by the use of captions, arrows, adjunct questions and colour, according to Dwyer (1972), Holliday (1981), Winn (1981), all cited in Peeck (1987: 135). Dean and Kulhavy (1981), cited in Peeck (1987: 132), showed that learners benefited more from a map when they were required to label each feature than in the case where the map was presented with labels already provided. Verhaegen (1983), cited in Peeck (1987: 132), obtained a similar result.

Guri-Rozenblit (1988), cited in Peeck (1993: 230), showed that an illustration in a social science text proved significantly more helpful for retaining information from the text when accompanied by a verbal explanation than without. Bernard (1990), cited in Peeck (1993: 230), also found that " illustrated text content was significantly better retained when the illustration had been given a verbal explanation than when it had not."

University of Cape Town

Rowe (1993: 126) suggest the following activities for learners to enable them to deal with illustrations in a systematic and instructionally productive manner:

- justifying the graphic treatment of an entity within the illustration
- classifying the entities used in the illustration
- comparing different representations of the same subject matter
- comparing different parts of the same illustration
- making modifications to existing illustrations
- linking the material in the illustration to existing background knowledge
- transforming aspects of the illustration into another representational form.

The purposes of these activities are to stimulate mental manipulation, which will result in a deeper understanding of the illustration.

However, learners' reading ability could influence the instructional effect of illustrations in many ways. According to Peeck (1987: 135):

> " Children who are relatively low in reading ability may direct more attention to pictorial accompaniments because they lack confidence in their ability to process text without regularly checking the illustration in search of 'clues' to the text's meaning."

Goldstein and Underwood (1981), cited in Peeck (1987: 135), agreed with the above-mentioned and concluded that, " the less competent the reader is, the greater the influence of picture information will be." Levie and Lentz (1982), cited in Peeck (1987: 136), also came to the conclusion that poor readers are helped more by illustrations than good readers.

University of Cape Town

According to Rusted and Colheart (1979), cited in Peeck (1987: 136), the enhancing effects of pictures may be more pronounced for poor readers than good readers. They observed the reading abilities of poor and good readers, and found that poor readers frequently moved their eyes from the passage to the pictures, whereas the good readers paid little attention to the pictures during reading.

According to Reid and Beveridge (1990), cited in Peeck (1993: 231), poor readers may shift their attention from the text to the picture at inappropriate moments and thus may learn less efficiently from the presence of illustrations than good readers do. However, researchers such as Holliday; Brumner and Donais; Koran and Koran, all cited in Peeck (1987: 136), found that low-ability learners may obtain more benefit from the presence of pictorial adjuncts than high ability learners.

The learners' level of prior knowledge, as well as their experience with the subject matter of the illustrated text, will have an effect on the interpretation and understanding of the illustrations. Joseph and Dwyer (1984), cited in Peeck (1987: 137), found that learners with a high level of prior knowledge generally outperformed learners with a lower level.

According to Mayer and Gallini (1990: 718), high knowledge learners build mental models spontaneously because of their repertoire of techniques for strategically using

University of Cape Town

their domain knowledge, and their strategies for representing information in the text visually.

To increase the educational effect of illustrations, the visual literacy, or aspects of it, of the learners should be improved. This occurs in a more or less systematic way in many classrooms, although there exist special programmes designed to improve children's dealing with illustrations. Examples of such programmes are the TAP (thinking about pictures) developed by Higgins (1979), cited in Peeck (1993: 231) in Australia. Another example of such a programme is one developed by van den Bosch (1979), cited in Peeck (1993: 231), where an attempt was made to encourage learners to activate their prior knowledge with regard to picture content, and to draw interferences from the pictures. Other programmes include the 'graphic information lesson' designed by Reinking (1986) and the SLIC strategies program (summarize, link, image, check) designed by Moore (1991) cited in Peeck (1993: 232).

In educational practice the recommended instructional interventions could easily be ignored by some of the learners and therefore might turn out to be ineffective unless more control over the learning activities can be achieved. According to Peeck (1993: 234) the learners must create an external and controllable product in response to the picture-orientated instructions. The processing of the learning material may be promoted, for example, by requiring the learners to produce pictures or parts of pictures themselves, rather than by providing them with the ready-made pictures. The

University of Cape Town

instructional interventions, and their implications for learning, are summarized by Peeck (1993: 235) in table 2.1 as follows:

Table 2.1 Instructional interventions and their effects on learning from text illustrations. (After Peeck, 1993: 235)

Instructional Intervention	Possible effects on picture processing	Risk of student ignoring intervention	Possibility of corrective feedback
Ask or tell learner to pay attention to illustrations	Small	Large	Small
Tell learner what to observe in illustrations *in general*			
Tell learner what to observe in a *particular picture*			
Tell learner to do something with illustration without controllable product			Small
Same as above, but with controllable product	Large	Small	Large

University of Cape Town

2.6 Theoretical framework with reference to the teaching and learning of illustrations in science and biology

This section of the review consists of two parts. In the first part the review focuses on the different aspects of visual literacy, and its implications in school settings. In the second part the review focuses on research findings and briefly discusses some theories of how learning occurs from graphics.

2.6.1 Theoretical framework for visual literacy

2.6.1.1 The concept of "literacy"

The meaning of the term literacy has expanded. Originally the term meant the ability to read and write. Therefore a literate person was one who could read and write. Nowadays, however, literacy is a broader concept that requires more than reading and writing, and one frequently comes across references such as *verbal literacy* (Hall, 1987 ; Holdaway, 1984), *media literacy* (Salamon, 1982 ; Johnson, 1977), *visual literacy* (Platt, 1975 ; Dondis, 1973), *computer literacy* (Provenzo, 1986), *technological literacy* (Tuman, 1992 a, b), *aesthetic literacy* (Kaelin, 1989), all these authors being cited in Seels (1994: 98). Nowadays *scientific literacy* and the like can also be included in the above-mentioned list.

University of Cape Town

2.6.1.2 Definitions of visual literacy

According to Hering (1980), cited in Seels (1994: 103), the concept of visual literacy is ill-defined because it is often defined as a set of competencies which are culturally biased.

Platt (1975: 5), cited in Seels (1994: 103), defined visual literacy as "people having the ability both to understand and to express themselves in terms of visual material, to enable them to relate visual images to meanings beyond the images themselves".

Braden and Walker (1985), cited in Seels (1994: 103), defined visual literacy as "to be visually literate is to be able to gain meaning from what we see and be able to communicate meaning to others through the image we create".

Heinich, Molanda and Russell (1982), cited in Seels (1994: 103), defined visual literacy as "the learned ability to interpret visual messages accurately and to create such messages".

Braden and Hortin (1982), cited in Seels (1994: 104), also defined visual literacy as "the ability to understand and use images, including the ability to think, learn and express oneself in terms of images".

Curtis (1987), cited in Seels (1994: 104), offered a variation of the definition, stating "visual literacy is the ability to understand the communication of a visual statement in any medium and the ability to express it with at least one visual discipline".

University of Cape Town

2.7 Theoretical foundations which have contributed to the knowledge and understanding of visual literacy

The theoretical foundations of visual literacy cover extensive areas of discourse, having developed from a confluence of theories of many disciplines that include linguistics, art, psychology and philosophy (Hortin, 1994: 6).

2.7.1 The linguistic foundations of visual literacy

There has been much debate about whether or not visual language can be described as a language in the linguistic sense. Some researchers have tried to show that the meaning in visual language could also be gained by understanding visual composition, syntax and elements. Others have argued that verbal language is designed to encode information logically, which visuals cannot do effectively (Dondis, 1973), cited in Hortin (1994: 6).

The influence of linguistics on visual literacy has been appreciable, and many writers have expressed the belief that visual language can help in the learning of a verbal language. Hortin (1994: 8) points out that " linguistics provide visual literacy with the concepts necessary to establish some connections between verbal and visual language. Linguistics also pave the way for the theory that learning visual language may help in learning verbal language."

University of Cape Town

2.7.2 The arts' foundation in visual literacy

The contribution of the arts in the development of visual literacy is Arnheims' (1969) theory on visual thinking , cited in Hortin (1994: 8), which may be the most important aspect of the visual literacy concept. Arnheim wrote:

> " Visual thinking calls more broadly for the ability to see visual shapes as images of the patterns of forces that underlie our existence – the functioning of minds, of bodies, or machines, the structure of societies, or ideas."

According to Arnheim, for visual thinking to take place, the person should be able to process information visually as well as verbally.

Writers who made a contribution to the development of art theory, in respects that have been useful to visual literacy development theory, include Blinkley (1974), Buettner (1975) and Parson (1976), cited in Hortin (1994: 9). These writers dealt with the "need for enjoying, interpreting and promoting, developing, or recognizing art as a basic need in the human experience, and helped to form the rationale for visual literacy from the discipline of art" (Hortin, 1994: 9).

2.7.3 Psychology's foundation in visual literacy

Perceptionists such as Gibson (1954) and Taylor (1960), cited in Hortin (1994: 12), have had a strong influence on the development of the visual literacy theory. According to perception theorists, in order to develop visual literacy, experience is needed to develop perceptual skills, and that perception is when a person becomes aware of something.

Developmentalists like Piaget also helped to define the parameters of visual literacy. Brainard (1976), cited in Hortin (1994: 12), wrote:

> " Visual literacy, then, is closely allied with the middle stage of development which involves representational skills. According to Piaget, it is only when that child has had wide experiences in each state, then that child is capable of abstract thinking."

University of Cape Town

Transactionalists such as Tach (1976) and MacLean (1976), cited in Hortin (1994: 6), on the other hand, differed from the perceptionists. They took an overview of the visual communication and its elements. For them " the perceptual behaviour of the individual becomes a transaction in which neither the individual nor the environment is regarded as a separate entity" (Hortin, 1994:13). If visual information is presented to viewers, together with a task specifying relevant purposes, then the transactional theorist believed that learning would take place.

Buber (1976), cited in Hortin (1994: 6), suggested that the mind has an important role to play in perception. Amney (1976), cited in Hortin (1994: 15) wrote:

> " 'Mind' is not achieved by (sic) formula, it requires a deep understanding of the subject matter, as well as a fundamental comprehension on the part of the producers of the true meaning of 'communication'".

2.7.4 Philosophy's foundation in visual literacy

The philosopher Turbayne (1970), cited in Hortin (1994: 6), had the most influence on the development of visual literacy theory.

Much of the philosophy that has had an impact on the development of visual literacy is concerned with metaphor. A metaphor is used to try to illustrate certain ideas, or to try to control the thoughts of others. However, a problem arises when the metaphor is taken literally, and then it becomes hard to distinguish the metaphor from reality. Turbayne (1970), cited in Hortin (1994: 16), elaborated on the myth of the metaphor: "There is a difference between using a metaphor and taking it literally. The one is to make believe that something is the case; the other is to believe that it is".

University of Cape Town

Turbayne (1970) said that the metaphor has a useful purpose and can be used, for example, in models, illustrations, etc.

Visual literacy needs to be trained. Feldman (1976), cited in Hortin (1994: 21), listed three implications that visual literacy has for education:

> " The most important is that there is a language of images and that it can be learned. Second, much of what many people know about the world has been learned through visual images, without the benefit of formal instruction on how to read them. Third, the several disciplines that study art constitute well-established ways of reading visual language."

University of Cape Town

2.7.5 Implications

The implications for this dissertation, of the above review of the linguistic, artistic, psychological and philosophical foundations of visual literacy are :

Firstly, that in school science and biology there must be a promotion of a high level of visual literacy, which clearly presupposes an ability to recognise the literal pictorial content, to enable learners to see beyond the representational qualities of the text illustrations and through to what they can identify as the intended meaning.

Secondly, that more local research should be done into the contextual visual needs and the abilities of the learners, caused by the varied levels of visual literacies and cultural backgrounds among learners.

Thirdly, that illustrators, writers and editors of South African textbooks should be given education in visual literacy, so that the style of illustrations can be

more appropriate.

2.8 Theoretical framework and theories of learning illustrations

Although a drawing may be well drawn and clear, there might be wide interpretations by different users. A novice might not see the parts whilst the expert sees them easily. Goldsmith (1984), cited in Buckley (2000: 898), characterized this continuum between the novice and expert reading of illustrations in terms of semiotic levels:

> " The syntactic level involves being able to discern the image or set of images. The semantic level involves recognising what the image represents based on relevant detail. The pragmatic level involves recognising not only the image and what it represents, but also the wider context."

On the other hand, Schnotz (1993) enquires as to how learners understand graphics in texts; how the text comprehension interacts with the graphic comprehension and how learners integrate verbal and pictorial information.

Different theoretical approaches to the cognitive processing of texts and graphics have been developed during the last two decades. The dual-code model of Paivio (1986), cited in Mayer and Moreno (1998: 312), proposes a verbal system for processing and storing linguistic information, and a separate nonverbal system for spatial information. These two systems can function independently, but they are also interconnected. According to Mayer and Moreno dual coding is able to explain the picture superiority effect (PSE).

University of Cape Town

A similar dual-code model has been supported by Kulhavy *et al* (1985), cited in Schnotz, Pickard, and Hron, (1993: 182). They proposed a theory of conjoint processing " which states that information is recalled better when it has been encoded verbally and pictorially". Baggelt (1989), cited in Mayer and Anderson (1992: 452), suggested an alternative theory to describe dual media learning, "where verbal information is transformed into a macrostructure through a verbal processing system, and visual information is transformed into a macrostructure through a visual processing system and these two channels are assumed to operate in parallel."

According to Mayer and Moreno (1998: 312), the primary assumptions of the dual-processing theory of working memory can be summarised in four stages as found by other researchers, namely:

- That working memory consists of an auditory and a visual working memory, which is similar to Baddeley's theory of working memory cited by Mayer and Moreno (1998).
- Each working memory store has a limited capacity consistent with, for example, Cowper's (1990) cognitive load theory cited by Mayer and Moreno (1998).
- Relative information is stored, selected and organised in a manner similar to Mayer's (1997) generative theory of multimedia learning cited by Mayer and Moreno (1998).
- Both pictorial and verbal information must be in the working memory at the same time, corresponding to Clark and Paivio's (1991) dual-coding theory cited by Mayer and Moreno (1998).

University of Cape Town

Other researchers (e.g. Anderson; Kosslyn; Pylyshyn) suggest a single code model in which all information is coded as abstract propositions (Levie, 1987: 10). Another model was the semantic-sensory model of Nelson (1979). According to Levie (1987: 10), " in this model the PSE is attributed to a more distinctive sensory code for pictures, or to a greater likelihood that pictures will be processed semantically."

Durso and his associates, cited in Levie (1987: 10), proposed a generic specific model " in which mental representations of pictures contain information specific to each picture whereas semantic information of a generic nature is encoded for words." On the other hand, Snodgrass (1984), cited in Levie (1987: 10), proposed a multilevel model " in which information from separate verbal and nonverbal systems is passed on to a single propositional store."

Researchers agree that learners construct mental representations during graphic comprehension and that these representations are used to solve certain tasks. However the mental representations constructed by the learners must capture critical features of the domain information depicted by the illustration. The mental representation constructed is characterised as a function of the information provided by the illustration and by the person's background knowledge.

According to Lowe (1993: 159), two types of knowledge are central to the construction of the appropriate mental representation, namely:

University of Cape Town

a) Domain-general knowledge, which refers to the component of the illustration on a visuo-spatial level, and

b) Domain-specific knowledge, which goes beyond the visuo-spatial level in order to represent mentally the meaning of the system depicted in the illustration.

In multimedia learning the learner must process information presented in, for example, visual and verbal mode. In this instance Mayer's (1997) generative theory of multimedia learning is relevant. According to Plass, Leutner, Chun, and Mayer (1998:26) this theory built on Wittrock's (1990) generative theory and Paivio's (1990) dual-coding theory, as well as offering extensions to both theories.

Plass *et al* extended this generative theory of multimedia learning to second language learning. According to them, second language learners have two separate verbal systems and a common imagery system, and translation of words will be stored in the second verbal system. This will have an additive effect on learning, and " words that are coded dually in two modes (verbally and non-verbally, e.g. pictures) would be learned better than those coded only verbally" (page 26).

University of Cape Town

2.9 Possible implications of this literature review for current science textbooks

Textbooks tend play an important role in science teaching. According to Stinner (1992), cited in Soyibo (1995: 344), " science teaching has been a textbook enterprise in the English speaking world since the 1820s." According to Harms and Yager (1981), cited in Soyibo (1996: 190), " 90 % of all science teachers in the USA use a

science textbook over 90 % of the time". According to Soyibo (1996: 190), in developing countries the learners' and the teachers' dependence on science textbooks is even more critical because:

1) Laboratory facilities are inadequate (King, 1990: 148);

2) Teaching is confined to a given syllabus of centralised examinations such as Matriculation examinations; and

3) The lecture method is the predominant teaching method (Glasgow, 1988: 20).

Textbooks make use of many types of visual aids that may help to teach difficult scientific concepts. However, many textbooks also include decorative colour photographs more for selling the book than for educating the learner.

The number of illustrations used in textbooks has increased in recent decades. Blystone and Barnard (1988), cited in Rowe (1990: 20), noted "the increase in biology textbook length was associated more with additional illustrations and less with additional text. The increase in the number of illustrations is reflected in all science textbooks at both secondary school and college levels."

According to Holliday (1990: 27), "Experts seem to agree that widespread use of fancy photographs merely adds pages to science texts without necessarily clarifying science concepts and processes."

The various functions of illustrations have been highlighted earlier in this review. They included, for example, motivating the learner; making reading more enjoyable;

University of Cape Town

and bringing excitement to the topic. The role of illustrations in textbooks is expanding in all disciplines. However, problems do still exist.

Some textbooks receive widespread criticism, and the value of their illustrations is often downplayed. According to Rowe (1990: 21), "Many textbook critics consider illustrations as irrelevant criteria upon which to base textbook selection". According to Evans *et al.* (1987: 89), "publishers agreed on the whole that considerably more attention and effort are given to illustrations and the design of books now, than in the past". Therefore illustrations in updated editions are livelier, more varied, more colourful and more frequent than in previous editions.

According to Soyibo (1994: 11), during practical assignments, learners often reproduce biology textbooks diagrams instead of drawing them from the actual specimens. Consequently, any errors in the textbook diagrams are mirrored in their drawings. Therefore illustrations must be accurate and well-labelled to be effective.

According to Rowe (1990: 25), "Textbook editors are very careful to keep the prose on grade level throughout the book, but the same is not true for illustrations". Consequently the detail in illustrations in science textbooks may often exceed the level of content presentation in the text.

The teachers' content knowledge may also be challenged, and sometimes many teachers are not even aware of errors in the illustrations, or incorrectly labelled illustrations. In the South African context, there are many teachers who may try to

University of Cape Town

'explain' an illustration without having seen the whole specimen or studied the sample, for example under the microscope. This fact has been introduced on page 1 of the thesis. This exacerbates the problem of content because, if the teachers are not sure of the illustration, they may be unable to help the learner to understand the illustration.

Teachers do not always take into account the complexity of an illustration when the learners must do an assignment. The learners themselves often might not study the content of an illustration. Therefore the learners may only glance at an illustration, and may not take the time and effort to work through the illustration. It is not even clear how learners extract information from the illustrations.

University of Cape Town

2.10 Gaps in the literature and how this study will complete some of these gaps

The contextual settings of the learners are not always considered in the literature. The mutuality of people and their social cultural environment must be considered to understand how the learners use illustrations. Most of the literature is from a Western point of view. In South Africa, with its diverse cultures, it is important to reach a set of criteria to evaluate the illustrations, which will be suitable for the South African learner.

In our multi-cultural society, some Xhosa-speaking learners are not frequently exposed to textbook visuals. With the present study it is hoped to find out how the Xhosa-speaking learner interprets and understand illustrations, and how this

understanding differs from the advantaged learners who tend to be exposed to pictures and graphics from an early age.

It is not clear how the learners and the teachers actually utilize the illustrations in classrooms. According to several teachers in Cape Town, some of the positive roles illustrations include motivating the learner and clarifying concepts. Disadvantages of illustrations include the possibility that they may be confusing and distracting to the learners. What is not really known is:

1) What attributes of an illustration makes it helpful for the learner?
2) How do the learners gain meaning from the illustration?
3) How do the illustrations influence the behaviour of teachers?

University of Cape Town

2.11 Chapter summary

In this chapter first the reasons for using illustrations in textbooks were presented. Then the problems that learners encounter, which may affect their interpretation and understanding of the illustrations, were described. Next, the strategies used in the teaching and learning of illustrations were presented. The research findings with reference to the teaching of illustrations were then reviewed, and possible implications for current science textbooks were presented. Finally, the chapter pointed out to some existing gaps in the published literature, and how this research may help to complete some of the gaps.

A description of the research methodology and procedures now follows in **chapter 3.**

CHAPTER 3

METHODOLOGY

University of Cape Town

CHAPTER 3

RESEARCH METHODS AND PROCEDURES

This chapter presents the research methods and procedures adopted to study the learners' problems encountered with biological illustrations, and their perceptions of them. The methodological aspects described in this chapter present the details of the overall research strategy; the data-collection instruments; the population and samples; the research setting; the samples in their contexts; the research design and procedures; the survey as a research method; procedures for the data collection; administration of the pilot studies; administration of the questionnaires; interviews; data capture and analysis; selection of statistical methods; limitations and delimitation of the research design and the chapter's summary.

University of Cape Town

3.1 Overall research strategy

The major method used in this research is survey sampling. Sample surveys can provide accurate estimates about the population that they portray. The following texts, describing methods used to design and evaluate survey research were consulted: Babbie, 1973; Cohen and Manion, 1985; Fraenkel and Wallen, 1993; McMillan and Schumacher, 1993; Van Dalen, 1966; Anderson, 1990; Keeves, 1988; Cohen, 1976; Delamont, 1992 and Chen and Manion, 1990.

3.2 The data–collection instruments

In the initial stage of the investigation a draft worksheet questionnaire was drawn up to evaluate certain illustrations of the New Nation Science textbook. Seven agreed specifications, provided by authors in the literature review, e.g. Amsden (1960), Ramsey (1989), Kearsey and Turner (1999), as well as by a team of lecturers at the Michealis School of Fine Art and professional colleagues at Groote Schuur Hospitals' Department of Medical Graphics, were used to grade, assess and rate the illustrations.

The researchers' own carefully constructed **textbook questionnaire,** which was professionally reviewed by colleagues at Groote Schuur Hospitals' Department of Medical Graphics, formed the basis for the major data collection. The questionnaire was used to collect information on the learners' perceptions of illustrations with regard to supplied criteria. A second smaller questionnaire, namely an auxiliary **pictorial questionnaire,** was also used to gather data with regard the content of selected text illustrations.

University of Cape Town

Two kinds of questionnaires were used in this research. The first questionnaire used closed and open response questions. A second questionnaire, namely an auxiliary pictorial questionnaire with open and closed response questions, was also used.

In developing the questionnaire, attention was given to the wording of the questions. To reach final consensus on the wording, seven successively modified versions of the instrument were produced. Five pilot studies were used to develop and

test the main research instrument, namely the textbook questionnaire. Two schools were involved in the feasibility studies to evaluate the wording and suitability of the questionnaire, which was modified and improved in response to the improvements suggested in the preliminary trials, as reported in section 3.10.

3.3 The population and samples

Ideally, research into problems of the science learners' perceptions and understandings of the illustrations should sample all schools. In practice, however, such a representative study would be fraught with difficulties in both the administration of the research and the interpretation of the results. A quasi-sample, comprising twelve high schools was selected out of a possible population of 120 schools. Schools chosen were geographically convenient and covered a representative range of advantaged and disadvantaged areas; and the teachers were willing to help.

(a) The learners

Twelve high schools were chosen for the main study. One hundred and fifty questionnaires were hand delivered to biology teachers for distribution to their learners in each of the twelve schools.

University of Cape Town

(b) The teachers

A sample of 29 science teachers, drawn from eight high schools, and 35 high and primary school teachers-in-training were issued with questionnaires by the researcher personally.

3.4 The location and administration of the research

Factors which favoured the final selection of the chosen schools, were: firstly, the researcher himself is a senior biology teacher and marker in the Senior Certificate examinations, and is therefore credible, respected by, and well known to many principals and biology teachers; and, secondly the researcher had easy access to these twelve high schools for repeat visits if necessary.

Several difficulties were encountered with the administration of the research:

1. Five schools insisted that the departmental procedures had to be followed before permission could be granted for the study to proceed.
2. Six teachers were reluctant to allow research to take place in their classes, even though permission had been granted by the principal as well as by the head of the biology department. However, they did co-operate.

3.5 The samples in their contexts

Sample 1 consisted of 800 science learners from four disadvantaged high schools in Khayelitsha. All spoke Xhosa as their home language. There were marginally more

University of Cape Town

females than males, and their ages ranged from 12 to 16 years. They participated in the year 2000.

Sample 2 consisted of 800 science learners from eight advantaged high schools in the Cape Peninsula. All spoke English as their home language and they were surveyed in 2000. Their ages ranged from 12 to 16 years, with an even distribution of males to females.

Sample 3 consisted of 35 high and primary Science teachers-in-training. They were all students at the University of Cape Town, studying towards their Postgraduate Certificate in Education in 2001.

Sample 4 consisted of 279 additional science learners from two high schools in Khayelitsha. They participated in 2001.

Sample 5 consisted of 160 additional science learners from four advantaged high schools in the Cape Peninsula, who also participated in 2001.

Sample 6 consisted of 29 high school teachers from various schools in the Cape Peninsula, who also participated in 2001.

University of Cape Town

Cluster sampling was used in this research, in that a specific number of convenient schools was randomly selected, and all the grade 8 and 9 learners in that particular school were then tested. Stage sampling was also used in this research. After selecting the schools, the grade 8 and 9 learners were tested. From within these classes, a number of learners were then further selected to complete the pictorial questionnaire

as well. Convenience sampling was also used, as some convenient schools that were willing to help were included as well.

3.6 The research design

The research plan consisted of two phases, which involved:

a) A succession of pilot studies to trial, amend and improve the questionnaires;

b) A survey using two different questionnaires (textbook-based and auxiliary).

a) The pilot studies

The details of the five successive pilot studies are set out below in section 3.10.

b) The questionnaires and survey

These were distributed by the researcher to the twelve high schools, together with copies of the textbook, to be given to the learners to ascertain perceived problems with regard to the illustrations in the textbook. Appendix 5 contains the textbook with the illustrations evaluated by the reader respondents who participated in this study.

University of Cape Town

Two questionnaires were used in this investigation:

(a) a textbook-based questionnaire,

(b) an auxiliary pictorial questionnaire. These instruments are reproduced in Appendix 2a, 2b and 2c respectively.

c) Interviewing

One summative interview, on the findings of the research investigation as a whole was conducted with one of the graphics experts mentioned above in 3.2.

3.7 Data collection

The researcher had to obtain multiple copies of the textbook. A letter was written to the publishers, requesting a donation of the textbooks (Appendix 1a). Permission was granted, and thirty books were provided to the researcher in April 2000 to conduct the research.

Principals of high schools were then approached, and a letter of introduction (Appendix 1b) and the nature of the survey was set out. Most principals gave their support for the research to be conducted, but felt that it was up to the individual teacher to participate in the research. The head of biology department then had to give the permission for the research to be conducted.

University of Cape Town

To overcome the problem of a potentially poor response, which would have reduced the validity and reliability of the research, individual teachers were approached by the researcher to elicit support and interest. The fact that the publishers issued the textbooks to the researcher, as well as the fact that recommendations would be proposed to improve the quality of the illustrations in future editions of the textbooks, impressed many teachers. Consequently, most teachers promised their full cooperation and support in the research.

The questionnaires, as well as the textbooks, were delivered to the different schools by the researcher, and collected by him. This strategy resulted in an almost 100 % complete data collection from most schools.

3.8 The survey research method

The method used in this research is survey sampling. According to Van Dalen (1966: 296):

> " Sampling helps a researcher select representative units from which he can gather data that permit him to draw inferences about the nature of the entire population.... And saves time money and energy."

In a survey, the information that is collected from a small sample can be generalized to a larger population (Cohen and Manion, 1990: 74).

Questionnaires are widely used to obtain facts concerning attitudes and opinions. Respondents are presented with carefully selected questions, which will elicit the data required to confirm or reject a hypothesis (Van Dalen, 1966: 301).

According to Cohen and Manion (1990: 207):

> " The questionnaire has become one of the most used, useful but also abused means of collecting information..... and permits the collection of reliable and reasonable valid data relatively simply, cheaply and in a short space of time."

3.9 Procedures for data collection

Sample 1: (800 Xhosa speaking high school learners)

University of Cape Town

The data were collected during the period May-September 2000. The questionnaires, as well as 30 copies of the textbook, were administered to the learners by the researcher, with the assistance of their class teachers. Because the researcher was not Xhosa-speaking, the class teachers had to assist in clarifying terms in their mother-tongue; for example "relevance to text"; "suitability to Africa" and "overall impression of the illustrations".

Sample 2: (800 Advantaged high school learners)

The data were collected during the normal school days in February- March 2001. The researcher obtained permission from the principal, who referred him to the head of the science department. The copies of the textbook and the questionnaires were left with the head of the department, who then gave it to the teachers concerned. The questionnaires and the textbooks were collected after a couple of days.

Sample 3: (35 Primary and high school science teachers-in-training)

Data were collected during the period March 2001. Permission was granted by the lecturer of the PGCE learners at the University of Cape Town to gather data during one of their class times. The questionnaires and copies of the textbook were given to the 35 trainee teachers (26 primary and 9 secondary) during their class lecture. After the completion of the textbook questionnaire, the auxiliary pictorial questionnaire was then also administered to the trainee teachers, which was then duly completed and collected by the researcher.

University of Cape Town

Sample 4: (270 Xhosa-speaking high school learners)

The data were collected during March 2001. The researcher administered the auxiliary pictorial questionnaire to the learners.

Sample 5: (160 Advantaged high school learners)

Their class teachers administered the auxiliary pictorial questionnaire during March 2001.

Sample 6: (29 High school science teachers)

The textbooks and the data-based questionnaire were issued to the teachers in November 2000. These were then fetched by the researcher after two weeks. In March 2001 the auxiliary pictorial questionnaire was administered to the teachers, and fetched from them again after two weeks.

University of Cape Town

3.10 Administration and outcomes of the pilot studies

The biology learners were asked to indicate whether, in their view, certain illustrations are an accurate scientific representation of what the textbook artist claims they are. Five pilot studies were subsequently conducted, as follows:

After the draft data-based worksheet was drawn up, the first pilot study was conducted to see whether the research topic was feasible. Sixty learners at one of the advantaged schools were selected and given the draft worksheet as well as the

textbook. The first group of 30 grade 8 learners encountered many problems in completing the initial worksheet. A second group of 30 grade 10 learners was then chosen to complete a modified version of the worksheet, after making some adjustments to it. In this second pilot study it appeared that the grade 10 learners had a better understanding of the illustrations and that they could express themselves better. Hence, the following changes were made to the data-based worksheet/ questionnaire:

a) The learners encountered problems with the assigned task of placing stars in the various columns. The system of star ratings was then replaced with a system of number ratings.

b) The learners had to choose their two best liked illustrations as well as the two illustrations which they liked the least. Spaces were provided at the end of the refined instrument in which the page numbers could be written down.

The instrument was then refined, and a third pilot study was undertaken at the same school but, in this case, ten new grade 10 learners were given the textbook as well as the worksheet. In this third pilot study no problems were encountered or reported by the learners. A fourth pilot study was then undertaken. In this study 51 grade 10 learners at a disadvantaged school were given the textbook as well as the data-based worksheet.

University of Cape Town

They were asked to complete the worksheet for one chapter only. It was intended to see whether there was any response inconsistency when working with a large group. It was also decided to extend this research to investigate differences in perceptions in respect to gender as well as age. The wording of the worksheet instrument was then changed to supply information with regard to age and gender.

To evaluate the **content** of some of the illustrations, and not only whether a learner "likes" or "dislikes" a particular drawing, a second data-gathering instrument, the smaller auxiliary **pictorial questionnaire** was formulated and provided to the learners. In the pictorial questionnaire, the learners were asked to identify two different illustrations, and to indicate whether a drawing was well drawn or poorly drawn. Then they were asked to recommend improvements, if any, to a particular drawing. Three pilot studies were then conducted with the pictorial questionnaire as follows:

University of Cape Town

Twenty grade 8 learners of one of the disadvantaged schools were selected and given the pictorial questionnaire. The learners encountered problems in the completion of the instrument and the following changes were made:

1) The question with regard to recommendations for improving the illustrations was changed to a set of close-ended questions.
2) The learners had to indicate whether they had previously studied the particular illustrations in class.

The pictorial questionnaire was then refined, and a second pilot study was

subsequently undertaken at the same school. In this case, ten grade 8 learners were given the data-gathering instrument. In this second pilot study no problems were encountered or reported by the learners.

To facilitate the answering of the questions by the disadvantaged learners, it was decided that the learners might answer the questions better if presented in their mother-tongue (Xhosa). Hence, a teacher at the same school was requested to translate the instrument into Xhosa. A third pilot study was then conducted. Twelve grade 8 learners at the same school were given the Xhosa version of the instrument (Appendix 2c). The learners answered the questions better than when it was given in English; for example, they answered the questions in full sentences, whilst in the previous questionnaire they supplied one word answers.

University of Cape Town

3.11 Administration of the final version of the text-based questionnaire

A questionnaire is the most widely used technique for obtaining information, and it is relatively economical, has standardized questions, it can ensure anonymity, and questions can be written for specific purposes (McMillan and Schumacher, 1993: 238). The literature was consulted to guide the design the questionnaire (Cohen and Manion, 1990; Anderson, 1990; Van Dalen, 1966; Babbie, 1973; Cohen,1976).

In the design of the questionnaire, attention was paid to the following guidelines:

a) The layout should be clear and easy to use.

b) The wording of statements should be unambiguous.

c) Instructions should be clear and concise.

d) Vocabulary should be simple and easy to read.

e) The length of the questionnaire also should be considered, such that the questionnaire can be completed within a 30- minute time limit.

f) It must minimize potential errors from the respondents.

g) The questionnaire must elicit answers as close as possible to the truth.

h) The instructions must be brief and easy to understand.

i) The questionnaire must be kept as short as possible.

j) Adequate space must be provided for answering the open-ended questions.

k) The printing of the questionnaire must be clear.

In the closed response questions, respondents chose between predetermined responses. Closed responses facilitate a rapid and accurate summary of results. The advantages of closed response questions include:

a) They allow uniformity in responses.

b) They are easy to administer and to fill out.

c) They keep the respondents' attention focused on the subject.

d) The data analysis is simplified.

e) The respondents' replies refer to the areas of concern identified by the researcher.

The disadvantages of closed response questions include:

a) They may fail to reveal respondents' motives (why they answer in the ways they do).

University of Cape Town

b) They do not always yield information of sufficient scope or depth.

c) They may cue the respondent with respect to possible answers.

In open response questions, the respondents may contribute any response that they wish. Open response questions have certain advantages, which include:

a) They give the respondents an opportunity to reveal their real motives.

b) They do not limit the range of possible answers.

c) They may produce responses which may draw the researchers' attention to a situation or aspect that was not anticipated when the questionnaire was drawn up.

(Van Dalen, 1966: 303)

The disadvantages of open response questions include:

a) The respondents may unintentionally omit important information if they do not have a cue to guide their thinking.

b) The respondents may not provide useful data if they are not highly literate, and if they do not give time and thought to questions.

c) Complex answers may be extremely difficult and time consuming to analyse.

(Van Dalen, 1966: 303).

When the pictorial questionnaire was designed, the following method was employed by the researcher. Open-ended questions were first used in a pilot study with a small group of respondents. In this manner salient factors were generated. Closed-ended questions were then used, which were based on the open-ended responses.

University of Cape Town

In the text-based questionnaire (appendix 2a), the respondents were asked to write down the number that best represents how they feel about the various illustrations using a scale from 1 to 5. This kind of attitude scale is called the Likert-scale.

According to (Anderson, 1990: 212), " Likert-scales provide a great deal of information in a short period of time and the number of people choosing each response is a simple and effective form of analysis. It is possible to use it in a factor analysis to look for underlying patterns of responses." The content of the text-based questionnaire was grouped as follows:

The first section of the text-based questionnaire required the respondents to grade the illustrations by choosing numbers in each column, according to the given criteria. The second section was open-ended. This section required respondents to choose their two most favoured and two least favoured illustrations, and to supply reasons for their particular choices. The third section of the questionnaire required the respondents to indicate whether they chose to "agree" or "disagree" whether certain illustrations really depict what the artist claims. The fourth section sought to collect the biographical data.

University of Cape Town

Appendix 2b and 2c presents the two different sets of illustrations which comprised the auxiliary pictorial questionnaire. In the first section of this questionnaire, respondents were required to identify two illustrations, and to indicate, with reasons, whether they perceived the illustrations to be well drawn or poorly drawn. In the second section, the respondents were required to indicate how a particular drawing could be improved. In the third section, respondents were given a series of five illustrations and five different

labels. They were then required to place the correct label next to the particular drawing. The fourth section elicited biographical response data.

In most cases the questionnaires were handed to the learners personally. In this manner The administrator could explain the purpose and significance of the study, clarify points, answer questions and motivate respondents to answer questions carefully and truthfully (Van Dalen, 1966: 302).

3.12 The interviews

Anderson (1990: 222) defines an interview as "a specialised form of communication between people for a specific purpose associated with some agreed subject matter". For the purpose of this research study, the definition of Cohen and Manion (1985: 241) is used. They define an interview as " a two person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives of systematic description, prediction or explanation".

University of Cape Town

Interviews create opportunities to find out what is in the respondents' mind – what they think or how they feel about something. According to Fraenkel and Wallen (1993: 385), " interviewing (i.e. the careful asking of relevant questions), is an important way for a researcher to check the accuracy of - to verify or refute - the impressions he or she has gained through observation."

Fraenkel and Wallen (1993: 385), classified interviews into four types, namely structured, semi-structured, informal and retrospective. All four types were used

structured, semi-structured, informal and retrospective. All four types were used in this research and are therefore briefly described.

According to Fraenkel and Wallen (1993: 385), " The structured and semi-structured interviews consist of a series of questions designed to elicit specific answers on the part of the respondents, to obtain information that can later be compared and contrasted... and are useful for obtaining information to test a specific hypothesis".

Informal interviews, on the other hand, do not involve a specific sequence of questioning, and their primary intent is to find out what people think and how the views of one individual compare with those of another.

The advantages of interviews include:

a) They are flexible and adaptable, and they can be used with many different problems and types of persons.
b) Verbal and non-verbal behaviour can be noted in face-to-face interviews.
c) The respondent can be motivated by the interviewee.
d) They result in a much higher response rate than the questionnaire.

(McMillan, 1993: 250)

The disadvantages of interviews include:

a) They have a potential for subjectivity and bias.
b) They have high cost and are time consuming.
c) The respondents may be unfavourable with the interviewee and unwilling to report their true feelings.

University of Cape Town

(McMillan, 1993: 251)

Individual interviews were planned to follow up the analysis of the data, if necessary. The main purpose of the interviews was to seek additional insights into the qualitative data obtained from the questionnaires.

Five high school learners from the disadvantaged schools, as well as five learners from the advantaged schools were conveniently available to be interviewed. However, after consultation with the graphic artist, it was felt that the learners and teachers had expressed themselves frankly and clearly enough in the questionnaires, often extensively, and therefore further in-depth-interviews were unnecessary.

University of Cape Town

3.13 Data capture

Quantitative data

For the textbook questionnaire, a frequency count was made of the responses of the yes/ no choices for 17 illustrations; and for the most favoured/ least favoured choices. The data were stored in the Microsoft Excel software programme in the form of tables.

For the pictorial questionnaire, a frequency count was made of the responses to the right and wrong identification of the illustration of the fly and the perlemoen; whether or not an illustration clearly represented an egg; whether two illustrations, namely the fly and the perlemoen were well drawn or poorly drawn; and connections were

The respondents' choices (on a scale of 1-5) for each of the six criteria were entered in a Statistica computer package. All raw data collected from the respondents were keypunched into the Statistica programme.

Qualitative data

Various reasons were given by the respondents for their choices of most favoured/ least favoured illustrations as well as for their agree/ disagree responses. They were captured as follows. Firstly, for each illustration, various reasons supplied by the respondents' choice were selected and quoted verbatim. Secondly, as mentioned on page 11 in chapter 1, the considerable amount of data will be merely presented as lists of commonly emerging suggestions for the 57 illustrations. The reason for using a list is to ease the of feedback to textbook editors, and the ease of presenting examples of evidence to support or modify the current theories of textbook illustrations.

University of Cape Town

3.14 Selection of statistical methods

To recognise meaningful patterns in the data (more than 350 variables for each of the more than 2000 respondents), descriptive statistics were utilised as a method to reduce the large amount of data to permit easy understanding and interpretation.

Usually a t-test for two independent samples with approximately normally distributed data and comparable variances was used to test the first null hypothesis. A chi-square

test for two independent samples was used to test hypotheses 2, 3, 4 and 5. This test is defined as a simple non-parametric test of significance applicable for nominal data where observations can be classified into discrete categories and treated as frequencies (Burns, 1997: 183). In tables where the frequency in a cell was less than five, Fisher's z exact probability test was used. For the 2x2 test, the following chi-square values are critical: 3.84 (5 % level) and 6.64 (1 % level) (Burns, 1997: 187).

3.15 Methodological limitations of the research

1) A complete response by all respondents is necessary, because the generalizability of the sample statistics may be jeopardized. Many teachers provided their full support and co-operation. Consequently many teachers requested more questionnaires. One problem that occurred was that, especially in the case of 1-2% of the Xhosa-speaking learners, some questionnaires were returned with the responses to individual items left blank. The researcher then had to decide whether to include the responses to incomplete questions, or to throw out that particular small set of responses entirely. However, the number of questionnaires returned (better than 99 %) exceeded the researchers' expectations, and therefore individual judgement could be made in such cases, where doubtful responses existed.
2) The question of credibility must be considered. Although the data-gathering instruments were thoroughly tested so that clearly understood results could be obtained, a question that can be asked is: How dependable is the data? Were the respondents truthful and honest when they answered the questionnaire?

University of Cape Town

This can lead to a validity problem. This problem can be tackled using both correlation and triangulation, which is used to interpret converging evidence from different, separate sources. Conclusions which are suggested by different data sources are far stronger than those suggested by one alone.

Additional limitations will be discussed in chapter 5, emerging from the presentation of the results in chapter 4.

3.16 Chapter summary

This chapter has presented and described the survey research method, as well as the formulation and development of the final data-gathering instrument.

A description has been presented of the population samples, procedures for data collection, the data capture and methods of analysis, and the proposed selection of statistical methods used. Some limitations of the research methods have been outlined, prior to a more detailed discussion in Chapter 5.

The results and findings of the research study are now presented in the following **Chapter 4.**

University of Cape Town

Next, in part C, the individual hypotheses are tested and analysed using t-tests; then further explanations, reasons and recommendations – as supplied by the teachers and learners with regard to the size, clearness, colour, etc. of individual illustrations – are presented.

Next, in part D, further hypotheses are tested and analysed on the agree/ disagree responses using chi-square; then further explanations, reasons and recommendations – as supplied by the teachers and learners of individual illustrations with regard to their yes/ no responses – are presented.

Finally, in part E, the findings with special reference to the illustrations of the fly; the perlemoen; the inside of an egg and the development stages of the chick are presented.

A comprehensive discussion of all these findings occurs in the next chapter.

University of Cape Town

For the analysis in parts A, B, C and D the **independent variables** are:

(i) the socio-economic status of the school (classified as "advantaged" or "disadvantaged" according to annual school fee levy);

(ii) the grade level of the advantaged and disadvantaged learners (grade 8 advantaged or disadvantaged; and advantaged or disadvantaged grade 9 learners);

(iii) the educational level of the respondents (learners or teachers); and

CHAPTER 4

RESULTS

&

FINDINGS

University of Cape Town

CHAPTER 4

RESULTS AND FINDINGS

In this chapter the results and findings are presented in five parts A to E.

First, in part A, the evaluators' responses are presented to the ten published illustrations in chapter 7 of the Grade 7 science textbook, which were assessed and rated concurrently by all of the 64 teachers and by 450 of the learners. It is suggested that if the rating scores of the advantaged and the disadvantaged learners and of the high school and primary school teachers are strongly correlated, then confidence can be placed in the honesty, trustworthiness and reliability of the respondent evaluators, and in the rating method as a research technique.

Then all forty illustrations are presented with their overall impression ratings by batches or discrete samples of the learners and the teachers. Altogether six illustrations are identified by consensus as definitely the best, and six illustrations as definitely the worst. Then the respondents' qualitative justifications and explanations for these overall findings are presented in depth.

Next, in part B, the overall response impressions to all forty illustrations are evaluated in separate batches of ten at a time. After the quantitative comparisons, extensive qualitative evidence is then quoted from the respondents to substantiate the main statistical findings.

University of Cape Town

(iv) the professional group of the teachers (high school-based or primary school-based).

The **dependent variables** are the evaluatory assessment ratings of the perceived quality of 40 different science textbook illustrations with respect to expressed level of satisfaction with:

i) size ii) clearness iii) relevance to text

iv) colour v) suitability for Africa vi) overall impression.

Adjudged quality was rated by each respondent using the scale 1 = very poor/ unsatisfactory illustration; 2 = fair illustration; 3 = a good illustration; 4 = a very good illustration; 5 = an excellent illustration.

In part C the repeated **null hypothesis** to be tested for each dependent variable against the independent variables is: " that, when rating the **quality** of a given textbook illustration, no significant differences will occur between the expressed levels of satisfaction of two given samples of respondents".

Biographical descriptions of the ten **samples** of volunteer respondent groups, together with the particular school textbook **chapters** of the selected **illustrations** evaluated by them, are summarized in table 4.1 on page 84. In total, there were 64 teacher evaluators and 1584 learner evaluators.

University of Cape Town

Table 4.1 An overview/ summary description of the volunteer respondent groups; their evaluated chapters; and their evaluated illustrations.

Group No.	Sample description	Sample size	Textbook chapter Evaluated	Description of the ten illustrations evaluated
N_a	Disadvantaged 8 and 9	N = 190	Ch. 2: Bricks that build our world	Asteroid; Dinosaurs; Properties of water; Lake; Greenhouse effect; Squid hunting; Water; Warming water; Foundation of earth; Shape of things
N_b	Disadvantaged 8 and 9	N = 178	Ch.1: Forms and function of life	Flea; Flea sucking; Lamp; fly; Swarming locust; Bees at work; Perlemoen,;Perlemoen; Spider's web; Poisonous spiders
N_c	Disadvantaged 8 and 9	N = 237	Ch. 5: Secrets of flight	Gull in flight; Penguin; Sunbird; Chicken; Flight into danger; Owl; Flying fishermen; Ostrich; Inside an egg; Development of chick
N_d	Disadvantaged 8 and 9	N = 252	Ch. 7: The flow of life	Days of big rain; Water cycle; Penguins in peril; Penguins; Jackass penguins; Kelp gulls; Kelp gull feeding; Hippos; Mussels; Platannas
N_e	Advantaged 8 and 9	N = 172	Ch. 2: Bricks that build our world	Asteroid; Dinosaurs; Properties of water; Lake; Greenhouse effect; Squid hunting; Water; Warming water; Foundation of earth; Shape of things
N_f	Advantaged 8 and 9	N = 237	Ch.1: Forms and function of life	Flea; Flea sucking; Lamp; Fly; Swarming locust; Bees at work; Perlemoen; Perlemoen; Spider's web; Poisonous spiders
N_g	Advantaged 8 and 9	N = 166	Ch. 5: Secrets of flight	Gull in flight; Penguin; Sunbird; Chicken; Flight into danger; Owl; Flying fishermen; Ostrich; Inside an egg; Development of chick
N_h	Advantaged 8 and 9	N = 200	Ch. 7: The flow of life	Days of big rain; Water cycle; Penguins in peril; Penguins; Jackass penguins; Kelp gulls; Kelp gull feeding; Hippos; Mussels; Platannas
N_i	High School Teachers	N = 29	Ch. 7: The flow of life	Days of big rain; Water cycle; Penguins in peril; Penguins; Jackass penguins; Kelp gulls; Kelp gull feeding; Hippos; Mussels; Platannas
N_j	Primary School Teachers	N = 35	Ch. 7: The flow of life	Days of big rain; Water cycle; Penguins in peril; Penguins; Jackass penguins; Kelp gulls; Kelp gull feeding; Hippos; Mussels; Platannas

University of Cape Town

FINDINGS

PART A: CONCURRENCE OF THE RESPONDENT EVALUATORS

- Textbook chapter 7: The Flow of Life, had ten illustrations which were evaluated on the five point rating scale by representatives from **all** the samples, i.e. by 28 of the 29 high school teachers, by all the 35 primary school teachers, and by 450 of the 1584 learners.

The mean ratings for the overall quality of these ten illustrations are presented in table 4.2 on pages 87 and 88. In order to check that each group was rating consistently, relative to the other comparable groups, table 4.3 on page 89 presents the inter-group correlation ratings obtained between the assessments of the four groups (advantaged and disadvantaged learners; high school and primary school teachers) for the ten common illustrations rated inclusively. All the inter-correlations are high and significant; i.e. the ratings of the primary and high school teachers correlate 0.92 and the ratings of the advantaged and disadvantaged learners correlate 0.93 which suggests that the rating exercise was taken seriously and consistently by most, if not all, the participants.

The numerical values of the teachers' and learners' ratings of the ten illustrations correlate between 0.70 and 0.76 which may be considered a notable set of agreements, considering the widely diverse nature of the four respondent samples with respect to age and level of education.

University of Cape Town

- However, in subsequent tables, namely 4.14 to 4.24, it will be shown that, in their ratings, the learners were more favourably disposed towards the illustrations' specified criteria than the teachers on 186 occasions, whereas the teachers were more favourably disposed towards the illustrations than the learners in their ratings on 52 occasions. This overall finding indicates that the teachers tended to rate more conservatively than the learners on the whole; and it is in this context that the following detailed results are presented.

University of Cape Town

Table 4.2. Overall impression ratings of ten illustrations in textbook chapter 7, by 200 advantaged learners (A), 250 disadvantaged learners (D), 28 high school teachers (HST) and 35 primary school teachers (PST).

Drawing	*Group*	*N*	*Mean Rating*	*SD*
Days of big rain	A	200	3.31	1.06
page 145	D	250	3.32	1.18
	HST	28	2.21	0.79
	PST	35	2.23	0.79
Water cycle	A	200	3.74	1.16
page 146	D	250	3.63	1.24
	HST	28	3.93	0.72
	PST	35	3.71	0.83
Penguins in peril	A	200	2.77	1.07
page 151	D	250	2.68	1.20
	HST	28	2.79	0.83
	PST	35	2.66	0.97
Penguins	A	200	3.50	1.19
page 152	D	250	3.34	1.28
	HST	28	3.61	0.83
	PST	35	3.00	0.88
Jackass penguins	A	200	3.34	1.13
page 153	D	250	3.36	1.23
	HST	28	3.11	0.79
	PST	35	3.06	0.87

Cont/ ....

University of Cape Town

Table 4.2 (cont.)

Drawing	*Group*	*N*	***Mean Rating***	***SD***
Kelp gulls	A	200	3.30	1.16
page 154	D	250	3.32	1.31
	HST	28	3.18	0.82
	PST	35	3.00	0.80
Kelp gull feeding	A	200	2.94	1.20
page 155	D	250	2.85	1.26
	HST	28	3.04	0.84
	PST	35	2.89	0.90
Hippos	A	200	2.59	1.14
page 157	D	250	2.61	1.24
	HST	28	1.86	0.85
	PST	35	1.94	0.84
Mussels	A	200	3.09	1.23
page 164	D	250	2.66	1.30
	HST	28	2.21	0.74
	PST	35	2.31	0.83
Platannas	A	200	2.89	1.29
page 166	D	250	2.86	1.34
	HST	28	2.93	0.77
	PST	35	2.27	0.86

University of Cape Town

Table 4.3 Correlations between the values of four groups' ratings of ten common textbook illustrations (A = 200 advantaged learners; D = 250 disadvantaged learners; HST = 28 high school teachers; PST = 35 primary school teachers).

Variable	A 200	D 250	H 28	P 35
A 200	1.00	0.93 *	0.71 *	0.76 *
D 250		1.00	0.70 *	0.73 *
H 28			1.00	0.92 *
P 35				1.00

* $p < 0.05$ marked correlations are significant

University of Cape Town

- Table 4.4 on page 91 records the responses of the 61 teachers and the 452 learners to ten illustrations in textbook chapter 7 when they were invited to select the *most favoured* and the *least favoured* illustrations out of the ten.

  The **water cycle** and the **penguins** were singled out as the best illustrations by both teachers and learners i.e. the respondent groups were reaching *concurrence* in their overall top ratings. The learners also included the **hippos**.

  The least acceptable illustrations of the ten to both the teachers and the learners were **days of big rain** and **hippos** (that is, the learners as a group tended to be

polarized on their impression of the illustration of the hippos). The learners were also polarized as a group on their acceptance or rejection of the **penguin** illustration.

Correlating the response frequencies of the teachers and learners for the most favoured illustrations of the ten yielded r = 0.54. However, a low correlation of only r = 0.19 was obtained as a measure of agreement on the most rejected (least acceptable) illustrations. This low correlation is accounted for by the polarization of the learners on the illustration of the **penguin**.

Because the correlation has been calculated using only ten items, the value of the correlation may be easily distorted by ambiguities in the responses to one illustration

University of Cape Town

Table 4.4 A frequency comparison of the most favoured/ least favoured responses by the school teachers (N = 61) and the science learners (N = 450) to the illustrations in textbook chapter 7.

Response frequencies						
Item	School teachers		Science learners		Chi- square or Fisher's z	p- value
	Most	Least	Most	Least		
Days of big Rain	3	**35**	89	**95**	21.26	0.00000 **
Water cycle	**42**	3	**130**	81	16.93	0.0001 **
Penguins in Peril	10	10	73	94	0.29	0.7667
Penguins	**19**	2	**93**	**154**	22.20	0.0000 **
Jackass Penguins	13	2	90	75	5.80	0.0131 *
Kelp gulls	16	3	77	61	5.58	0.0345 *
Kelp gull Feeding	15	6	64	70	4.07	0.0747
Hippos	2	**42**	**111**	**108**	31.83	0.00000 **
Mussels	3	22	72	97	8.60	0.0067 **
Platannas	6	13	82	83	2.24	0.2096

* $p < 0.05$ shows significant differences between samples 1 and 2
** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Both teachers and learners single out the illustration **Water cycle** as most favoured of the ten. **Hippos** is also favoured by the learners.

Hippos are identified by both groups as the least acceptable. **Days of big rain** and **Penguins** are also identified as the least acceptable by the learners.

PART B: PRESENTATION OF THE MAJOR FINDINGS

4.1 Overall quantitative findings

Tables 4.5 to 4.9 present the responses of the samples of the 1584 learners and the 61 teachers to the forty illustrations firstly, in terms of comparisons of their **overall** impressions of each rated illustration. With batches of illustrations presented ten at a time, the most favoured and the least favoured ratings are recorded and highlighted. Underneath each table the names of the best and worst illustrations, relative to each other, are noted, but for the discrete batches of ten.

Overall, of the 40 illustrations evaluated, each one rated according to six different specifications, only three illustrations, namely the **chicken** (textbook page 100), the **hippo** (textbook page 157) and **days of big rain** (textbook page 145) received mean ratings of less than 2.00 ("fair") on at least one of the six assessment criteria; so these three illustrations will be referred back to the artist.

University of Cape Town

Table 4.5 A frequency comparison of the most favoured/ least favoured responses by the 190 disadvantaged (N_a) vs. 172 advantaged learners (N_e) for ten illustrations in textbook chapter 2.

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Most	Least	Most	Least		
Asteroid	31	**51**	23	**73**	4.01	0.0659
Dinosaurs	**45**	49	**55**	36	2.65	0.1384
Properties of water	**58**	26	**47**	22	0.02	0.9589
Lake	**49**	32	43	21	0.69	0.5109
Greenhouse Effect	31	35	33	43	0.18	0.7989
Squid hunting	24	**56**	37	**51**	2.63	0.1441
Water	22	39	46	31	7.63	0.0096 **
Warming up water	23	29	23	32	0.06	0.9549
Foundation of earth	43	34	33	34	0.62	0.5334
Shape of Things	30	38	**47**	38	1.89	0.2258

University of Cape Town

** $p < 0.01$ shows a highly significant differences between samples 1 and 2

Both advantaged and disadvantaged groups single out the illustration " Dinosaurs" and **Properties of water** as most favoured. **Lake** is also favoured by the disadvantaged learners, and **Shape of things** by the advantaged learners.

Asteroid and **Squid hunting** are identified by both groups as the least acceptable of the ten.

Table 4.6 A frequency comparison of the most favoured/ least favoured responses by the 178 disadvantaged (N_b) vs. 237 advantaged learners (N_f) for ten illustrations in textbook chapter 1.

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Most	Least	Most	Least		
Flea	25	41	16	**84**	10.23	0.0014 **
Flea sucking	31	31	30	**86**	10.45	0.0022 **
Lamp	51	39	43	48	1.61	0.2633
Fly	**75**	26	**109**	18	4.84	0.0424 *
Swarming Locust	40	32	57	29	1.90	0.2244
Bees at work	37	33	60	46	0.024	0.7382
Perlemoen (1)	19	**49**	18	**99**	4.24	0.0618
Perlemoen (2)	30	32	36	36	0.03	0.9897
Spider's web	30	34	**73**	18	18.74	0.0000 **
Poisonous Spiders	24	**45**	47	22	15.35	0.0002 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

Both advantaged and disadvantaged groups single out the illustration **Fly** as most favoured. **Spider's web** is also favoured by the advantaged learners.

Perlemoen is identified by both groups as the least acceptable. **Flea** as well as **Flea sucking** is also identified as the least acceptable illustration by the advantaged learners, but this may be an emotional response, rather than a judgement of the quality of the artistry in the flea drawings.

University of Cape Town

Table 4.7 A frequency comparison of the most favoured/ least favoured responses by the 237 disadvantaged (N_e) vs. 166 advantaged learners (N_g) for ten illustrations in textbook chapter 5.

Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Most	Least	Most	Least		
Gull in flight	30	25	57	44	0.05	0.9534
Penguin	31	13	51	39	2.37	0.1772
Sunbird	38	**59**	56	**57**	2.28	0.1709
Chicken	**68**	**68**	**74**	**57**	1.13	0.3475
Flight into Danger	24	23	30	49	2.06	0.2114
Owl	34	29	54	53	0.19	0.7777
Flying Fishermen	24	33	48	37	2.82	0.1318
Ostrich	25	47	43	47	2.80	0.1303
Inside an egg	26	22	43	32	0.12	0.8737
Development of chick	42	29	38	31	4.55	0.0483 *

* $p < 0.05$ shows a significant difference between samples 1 and 2

University of Cape Town

Both advantaged and disadvantaged groups single out the illustration **Chicken** as most favoured.

However, **Chicken** and **Sunbird** are identified by both groups as the least acceptable.

Table 4.8 A frequency comparison of the most favoured/ least favoured responses by the 252 disadvantaged (N_d) vs. 200 advantaged learners (N_h) for ten illustrations in textbook chapter 7.

Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Most	Least	Most	Least		
Days of big Rain	18	41	**71**	**54**	11.09	0.0015 **
Water cycle	**59**	**53**	**71**	28	8.05	0.007 **
Penguins in Peril	29	47	44	47	1.75	0.2437
Penguins	45	49	48	55	0.03	0.9717
Jackass Penguins	39	36	51	39	0.36	0.6582
Kelp gulls	26	31	51	30	4.08	0.0648
Kelp gull Feeding	18	43	46	27	14.95	0.0002 **
Hippos	**49**	**54**	**62**	**54**	0.75	0.4638
Mussels	33	**55**	39	42	1.96	0.2140
Platannas	32	43	50	40	2.72	0.1356

** $p < 0.01$ shows highly significant differences between samples 1 and 2

Both advantaged and disadvantaged groups single out the illustration **Water cycle** and **Hippos** as most favoured. **Days of big rain** is also favoured by the advantaged learners.

Hippos are identified by both groups as the least acceptable. **Water cycle** and **Mussels** are also identified as the least acceptable by the disadvantaged learners, and **Days of big rain** by the advantaged learners.

University of Cape Town

Table 4.9 A frequency comparison of the most favoured/ least favoured responses by the high school teachers (N = 29) and the primary school teachers (N = 32) for ten illustrations in textbook chapter 7.

Response frequencies						
Item	High school Teachers		Primary school Teachers		Chi- square or Fishers	p- value
	Most	Least	Most	Least	z	
Days of big Rain	2	**15**	1	10	0.05	0.6876
Water cycle	**19**	1	**23**	2	0.16	0.8411
Penguins in Peril	4	4	6	6	0.21	0.6750
Penguins	12	1	7	1	0.13	0.6286
Jackass Penguins	2	1	11	1	1.30	0.8494
Kelp gulls	7	1	9	2	0.11	0.7628
Kelp gull Feeding	7	1	8	5	1.64	0.4345
Hippos	1	**21**	1	**21**	0.00	0.4692
Mussels	1	12	2	10	0.48	0.9411
Platannas	4	1	2	12	7.36	0.0313 *

* $p < 0.05$ shows significant differences between samples 1 and 2

University of Cape Town

Both high school and primary school teachers single out the illustration **Water cycle** as most favoured.

Hippos are identified by both groups as the least acceptable. **Days of big rain** is also identified by the primary school teachers as the least acceptable.

4.2 Qualitative results [pertaining to tables 4.5 to 4.9]

For ease of presentation, this section presents a combined condensed summary in list form, of the more than 300 000 descriptive reasons given for the most favoured/ least favoured illustration choices made by the science learners as well as the school teachers. Photocopies of many of these hand-written reasons are reproduced and attached in Appendix 4. Representative examples of the respondents' written comments are quoted *verbatim* as follows:

4.2.1 For the least favoured illustration, **asteroid**, according to the learners, some of the representative comments were as follows:

- "It is too small, too little detail and does not explain enough."
- "The colour is too poor."
- "It is small and has no colour."
- "Too little information provided."
- "I feel that more colour should have been supplied, as well as the size."
- "The picture looks good, like the real thing."
- "It was not that interesting, there was no labels."
- "The picture is very dull. They could have labeled it more. I don't know what is going on."
- "It is very small and hardly have dark colours in it."
- "It only consist of one colour and is not clear."

University of Cape Town

For the remaining 39 illustrations, the learners' recorded verbatim comments are:-

4.2.2 **Dinosaurs**

- "The colours is clear."
- "The picture and the colour looks real."
- "The picture is very colourful."
- "It is very clear and you can learn a lot."
- "The picture and the colour looks real."
- "It was excellent and interesting. I think it was great."
- "There were no labels - the colour was very bad. The dinosaurs blended in with the background, so you cannot see them properly."
- "The colours used are excellent and the story goes perfectly together."
- "The picture is clear and it looks real."

4.2.3 **Properties of water**

- "To little labels, and the size to small."
- "The water is not so colourful."
- "It illustrates the process clearly."
- "Because the colour is bright and beautiful it caught my attention."
- "I like the picture because of the colour. It has really captured my eyes and is also relevant to the text."
- "It must get more labels and colour to tell you more about the picture."

University of Cape Town

- "It's clear and bold and I think by just looking at the drawing it explains the properties of water."

4.2.4 **Lake**

- "It is too dark, not enough light, too little explanation."
- "It does not have a nice colour."
- "It does not explain anything about a lake."
- "The water looks very black and looks like a dirty river."
- "The picture shows all the plants, mountains and flow of the lake."

4.2.5 **Greenhouse effect**

- "The picture is too small and not enough labels."
- "The picture does not have a nice colour."
- "It does not have a lot of information."
- "It gives the real meaning for the thing."
- "The picture is excellent and there is a lot of colour."
- "It was clearly drawn and labelled good."
- "It actually shows what happens in a greenhouse, but in a miniature version."
- "The labels is very clear, so it makes it easy to understand."
- 'It gives me a better understanding."
- "It's self explanatory, very colourful and stands out."
- "It is not realistic because the sun is shining in the house."

University of Cape Town

- "The drawing is well drawn and the information is according to the illustration."

4.2.6 **Squid hunting**

- "The colour of the picture is too dull."
- "It shows what you can't see underwater."
- "The picture makes the topic exciting to read."
- "There should be more labels."
- "They gave very little information on how the whale catches the squid."
- "The pictures great. It looks real and the colours represent the original things."
- "It looks almost like it is real - like a photo."
- "It was a great sketch. That's what impressed me the most. The text does take too long to get to the point."
- "You don't understand what is going on and it does not say what squid hunting is."

4.2.7 **Water**

- "You can't really see what is going on."
- "It is unclear and has little colour."
- "It tells you more about the topic."
- "The picture of the water was poorly drawn and the colours very dull."
- "The colour was very poor and the labels very poor."
- "I don't like it because water are not like that. I do not know the colour of the water but it does not look like that."

University of Cape Town

4.2.8 **Warming up water**

- "It shows a good explanation of what you are talking about."
- "It does not have enough labels and the picture is dull."
- "It is clear and very realistic and there is a few labels."
- "The sketch is fine but they could have made it bigger and have more information."

4.2.9 **Foundation of the earth**

- "The picture is clear and the picture size is right."
- "The picture has no labels and a person won't understand it"
- "It has lots of information."
- "It has a lot of labels, the colour is good and there is lots of information."
- "It shows everything about the earth. It has all the labels to identify it and you can see it clearly."
- "It is very clear, it catches your eyes fast, suitable for reading and not many bright colours."
- "I think it was confusing because some children won't understand it."
- "It drawed my attention very quickly because it is colourful and it gives a lot of information."
- "It was very accurate."
- "It has realistic colours and show all the labels to it."
- The colours is bright and it explains everything they are saying."

University of Cape Town

4.2.10 **Shape of things**

- "The picture is not clear enough and the size is too small."
- "It was drawn very good and the colours were nice."
- "It was highly informing."
- "The picture is bright and you can see clearly."
- "There is not enough colour and it could have been drawn bigger."
- "It is not clear and is also confusing.

4.2.11 **The flea**

- "The colour is not right and it is too small."
- "It is not colourful."
- "There is no labels."
- "It is a very small picture."
- "You can't see the flea in the dark."
- "Not a lot of information was given."
- "There was no labels, colour wasn't good hardly any explanations."
- "It doesn't give you information what he is doing (information) on the picture."

4.2.12 **Flea sucking**

- "The drawing was poor and no facts."
- "There are lots of colour in the picture." (sic)
- "There was no labels and the colour of the picture was not at all bright colours."

University of Cape Town

- "I could see it very clearly, and it was a big size."
- "There was no explanation, colour wasn't good and hardly explanation."

4.2.13 **Lamp**

- "It's not colourful."
- "The colour was not nice and it did not look right."
- "It does not look like a lamp."
- "No colour and labels."
- "Because I can see it clearly and it is understandable."
- "It is small and there is no labels."
- "Do not have labels, not big enough, no attraction."
- "The colour does not look right at all. I never new it was a lamp."
- "It has too much dull colours in it and has no labels."

4.2.14 **The fly**

- "It looks real to me."
- "It looks perfect."
- "The picture looks clear."
- "The picture was colourful, so that anyone can see the picture or the colours."
- "Many colours and it is big."
- "Looks beautiful and colourful."
- "It is very clear and big enough. It just needs more colour in it.."
- "It is a good picture and all the labels are named and lots of information is given."

University of Cape Town

4.2.15 **Swarming locust**

- "The colours of the locust was nice and clear, and I liked the green colour."
- "It was very clear and a good colour."
- "Because it has a lot of colour and I could see clearly."
- "It is colourful and a big size."
- "It has a lot of colour in the picture, and I could see clearly on the page and they gave lots of information."
- "There was no clear picture, no labels hardly any information."
- "It does not give the information, like what the locust is doing or what it is eating."

4.2.16 **Bees at work**

- "Not very clear and no labels."
- "It is full of colour and pretty."
- "I like the picture because you learn about different types of bees as well as the nice colours."
- "You can hardly make out what is going on and is not clear enough."
- "It had poor colours and sizes and had no labels."

4.2.17 **Perlemoen**

- "It does not look nice."
- "The colour and size was not right."
- "I could not make out what it was and the colour was not nice."
- "The size of the drawing is small and there is not a lot of facts."

University of Cape Town

- "It was very hard to see whether it was a perlemoen or not."
- "You can't see what is going on."
- "It was small and had no information."
- "I cannot make out anything from the sketch."
- "It is not very clear what it really is."
- "You could not see clearly the picture and it need more colour."
- "It is small, not clear, no labels, the size is small and you cannot make out what is going on."

4.2.18 **Perlemoen**

- "It looks very colourful."
- "You can se the perlemoen very clearly, and it also shows you the information on the page."
- "It is nor very colourful and not big in size."

4.2.19 **Spider's web**

- "You can see what is going on."
- "There was excellent taste of colour and interesting facts."
- "It has lots of detail."
- "Excellent use of colour and the size was great."
- "The colour was nice and you can see it clearly."
- "The colour is beautiful and very clear."
- "It was a favourable drawing."
- "It was nice and big and you can see everything so clearly."
- "It is big and has beautiful colour."

University of Cape Town

- "You can see just by looking at it that it is a spider."
- "The drawing is small and gives us no labels of the body parts of the spider."

4.2.20 **Poisonous spiders**

- "It was very colourful."
- "The colours match perfectly and attracts my attention."
- "It was clear and you could see what was going on."
- "It was colourful, but also too small and no label information."
- "No labels were given, it was not so big and no information."

4.2.21 **Gull in flight**

- "The picture did not look very nice and did not show much information."
- "The seagull takes the whole picture."
- "The picture is not very clear."
- "It was a poor colour and it was not very good labeling."
- There is not a lot of labels and the size is too big."
- "It was very clear and was relevant to the text."
- "The colour of the bird goes with the blue/green water."
- "Not enough information is provided."

4.2.22 Penguins

- "The penguin is standing on dry land."
- "The size was not to good."
- "It was small and it's colour poor."
- "The penguin does not look realistic."

University of Cape Town

- "It is a little dull and is quite small."
- "The background looks very dull and it is not bright inuff."
- "The colour of the picture was not that clear."
- "The penguin needs to be in a cool/ cold area."

4.2.23 Sunbird

- "It is a beautiful drawing with lots of colour."
- "The colours are very good and it relates to the writing."
- "It had excellent colours, the labels were good and overall it was good."
- "The picture was very clear and the size was just it wasn't difficult to see."
- "The colours was excellent and that was a beautiful bird."
- It is not labeled well."
- "It was a clear and colourful picture."
- "The drawing is clear and bright."
- "It was very attractive because of the bright colours and it was easy to make out."
- "It is colourful and looks like the real bird."
- "It catches my attention with the colour and there's a lot of interesting information."

4.2.24 Chicken

- "The chicken has no colour and has a knife through it."
- "It was drawn with no colour and was very dull."

University of Cape Town

- "The picture was black and white and at first I did not know what they were talking about."
- "The drawing was understanding but the color was unsatisfactory."
- "The colour is not great and it does not look a lot like a chicken."
- "I thought it was something else when I looked at it, so it wasn't clear."
- "I rated it low because I didn't know it was a chicken until I looked at it again."
- "I really cannot make out if it's a chicken or not."

4.2.25 Flight into danger

- "It did not have any labels."
- There is not a lot of information and it's text wasn't precise and to the point.
- "It looks life-like."
- "It is clear and also very colourful."

4.2.26 Owl

- "The owl is one of the few illustrations that suit its habitat."
- "The picture is very clear and it look like it is real."
- "The owl was very big so there was no difficulties there"
- "It is coloured in beautiful."
- "The drawing was very accurate and the originality of the colours and the notes was clear."

4.2.27 Flying fishermen

University of Cape Town

- "The drawing was not clear."
- "The drawing was understandable but the colour was dull."
- "I rate it low because it wasn't very clear."

4.2.28 Ostrich

- "The ostrich looks so unreal."
- "The ostrich has nice colours and a good background."
- "It is very clear and is a beautiful picture."
- "It has a lot of colours and is excellent."
- "It attracts my attention because the colour is bright."

4.2.29 Inside an egg

- "Everything in the illustration is very clear."
- "Little information is supplied. Only questions are asked."
- "You can see everything clearly and it has all the labels."
- "They labeled it so you can learn what it is about, and the size is big so that you can see it."
- "The labels and clearness was excellent and I could learn a lot from it."
- "It is very realistic."
- "They show every detail that happens before a chick is born."
- "The drawing is very clear and the labels are very good."

4.2.30 Development of the chick

- "It shows you clearly how the chick develops."
- "They made the drawing so real."
- "The way it hatches as if it's real to me."

University of Cape Town

- "The labels and the colours are great."
- "The illustrations were great and the colour made the drawing understanding."
- "The labels were well given. It looked like a real thing. There was a lot of information."
- "The drawing was precise and you could see everything when the chicken hatches."
- "The drawing was to the point and excellent."
- "The colour and technique of the picture is good."
- "The drawing has good colours and show the development accurately."

4.2.31 Days of big rain

- "The colour is very bright and I like illustrations that's colourful."
- "It is clear and understandable."
- "I like this picture because it is so bright and clear. I can see everything."

4.2.32 Water cycle

- "Water is very good for our body and children."
- "I like water cycle because it is good for us and it's clear."
- "The picture is beautiful."
- "The picture is very good and so clear. The colour is bright and so nice."
- "It tells us a lot of information."
- "It is clear, the size is big and the colour is bright."
- "It tells you everything you want to know. The picture is clear."
- "It is big and colourful and it has space for labels."

University of Cape Town

- "The picture is clear and it shows how water runs downwards."
- "The picture is very attractive and colourful."

4.2.33 Penguins in peril

- "It is clear and understandable."
- "The colour is very dark and I don't like the bird."
- "The colour is very dark and the labels are not so good."
- "The size is very clear and the colour is not bad."
- "The picture is too dark, but I can see what's going on."
- "You cannot see the penguin clearly."
- "It is dull and has almost just one colour."
- "The poor penguins are full of mud and dirt."
- "There is no colour in the picture and it is very small."
- "The penguin is not clear enough, and penguins are not black, they are black and white."

4.2.34 Penguins

- "It's colour, clearness, size and labels are excellent."
- "The colour was great and the picture was big."
- "It is a nice size and so colourful."
- "The colour of the penguin was excellent to see."
- "It looks like a picture that is actually there in reality."
- "It is a nice picture but there is no colour in it."
- "Even though the drawing is allright, there is no relevance to the text."

4.2.35 Jackass penguins

University of Cape Town

- "They tell you everything you want to know and the picture is also clear."
- "It is a nice picture and its relevance to the text is nice."
- "It is excellent and clear and the colour is good."
- "The picture is colourful and it attracts many people."
- "They are like that on TV."

4.2.36 Kelp gulls

- "The colour is beautiful."
- "It has nice colours and the drawing are drawn perfect."
- "You cannot see the colour in them."
- "The picture is clear and explains everything you need to know about it."
- "The picture looks realistic."
- "The picture are clear and the text explain everything."

4.2.37 Kelp gull feeding

- "It looks almost real."
- "It is a great picture and have great colours."
- "I understand it clearly."
- "You can see the way the gull is eating the frog."

4.2.38 Hippos

- "The information is good but the drawing is bad."
- "The picture is not clear and the colours are bad."
- "It has a dull colour."
- "The colour is not good and it is not very clear to me."
- "I don't loke the hippo because they are very big and strong."

University of Cape Town

- You can't see the hippo right and the colour in the page is too dull."
- "It is not clear and you cannot make out what it is."
- "It looked very unpleasant and did not look like a real hippo would look like."

4.2.39 Mussels

- "The colour is too dark."
- "I cannot see what is going on."
- "The picture is not colourful."
- "It is one colour only and I didn't recognise what it is."

4.2.40 Platannas

- "I didn't understand it."
- "It's colour and size is excellent."
- "I hate platannas because the live in dirty river and they are not good."
- "It is good to look at because you can see everything."

University of Cape Town

The teachers' written comments on the choices for the most favoured/ least favoured illustrations are quoted *verbatim* as follows:

4.2.41 Days of big rain

- " The picture is too small."
- "It lacks impact for the reader, especially as this is the first page of the chapter."
- "It is unclear and very small, and I can hardly see what is going on."
- "The drawing is too small and does little to illustrate a particular concept."

4.2.42 Water cycle

- "The illustration is clear, using colours to enhance it."
- "It is a clear drawing and the entire water cycle can be seen."
- "The drawing style and picture is clear- it is easy to see what is happening in the picture, although the labels are badly placed."
- "The drawing is clear and encapsulated everything needed to teach the topic."
- "Clear, illustrative, fairly comprehensible and comprehendible drawing."
- "It is understandable, colourful and clear."
- "Very simple, clear illustration which is easy to understand."
- "It does not show the way in which the water cycle goes"

4.2.43 Penguins in peril

- "It is clear to identify what has happened to the bird."
- "The drawing clearly shows the peril (danger) the penguins are in, especially by showing the oil slick dripping off the animal."
- "A photograph should have been used to show the suffering - a illustration does not convey this."

4.2.44 Penguins

- "True reflection of the birds."
- "It is clear to everyone, you cannot doubt to mention what type of bird is shown."
- "It is clear, it is easy to identify what kinds of birds these are."

University of Cape Town

- "It describes exactly what the penguins look like and their behaviour."
- "Clearly and accurately drawn."
- "The drawing is accurate and clear. It is one that will be remembered easily."
- "It shows exactly how penguins look like and how they live."

4.2.45 Jackass penguins

- "Does not give any indication what is different about jackass penguins."
- "The penguins are clearly shown playfully feeding. The picture clearly show how they look and act on land and water."
- "Cannot see the distinction between penguins and jackass penguins."

4.2.46 Kelp gulls

- "How does the shell get into the air?"
- "It relates to the text. It is a clear drawing and depicts reality."
- Because it demonstrates how kelp gulls opens mussels, it opens up the discussion further."

4.2.47 Kelp gull feeding

- "The information about feeding is not relevant to the practically feeding shown in the picture because feeding on crops and other birds instead of frogs."
- "Not relevant - talking about 'powerful' beaks, but shown eating very soft food. Also gives the impression that frogs are common food for gulls, which is not entirely accurate."
- "Zooms in what the text is talking about."

University of Cape Town

- "It showed the topic clearly and uses bright colours."
- "It is very clear, large and simple."

4.2.48 Hippos

- "Bad illustration, bad use of colours and it is small."
- "It does not show what a hippo really looks like."
- "Untidy drawing, no colour contrast, and can hardly tell what the subject matter is."
- "Not a clear drawing - would not recognise the hippo."
- "A poor representation. One is going to the trouble of colour pictures, why not a photograph?"
- "A child cannot tell what it is. It is not clear or big enough."
- "One cannot really tell from the drawing if it was a hippo."
- "It is confusing and one would have to stare at it for a while to figure out what it is."
- "It was unclear and might confuse children. Not visually appealing."

4.2.49 Mussels

- "Bad picture, doesn't represent mussels whatsoever."
- "A person not knowing anything about mussels won't be able to know that these are mussels; the picture is also too dark."
- "It does not have much relevance to the text and do not look like mussels."
- The drawing is very 'empty'- no labels to clearly see why the mussels is an animal - also not relevant to the text."
- "A much better drawing of mussels could have been drawn."

University of Cape Town

4.2.50 Platannas

- "With the knowledge of platannas and frogs, it is a clear picture that you cannot confuse platanna with frog; it is a platanna and its habitat is also shown."
- " The drawing is a bad one. I have never seen a platanna look like that."
- " A platanna doesn't look like that frog because its feet are very webbed and its shape differs."
- "The clearness and colour wasn't very good."
- "We still don't know what a platanna looks like."

University of Cape Town

PART C: COMPARISONS BETWEEN THE EXPRESSED LEVELS OF SATISFACTION WITH THE TEXTBOOK ILLUSTRATIONS BY DIFFERENT SAMPLES OF RESPONDENTS

The repeated null hypotheses to be tested in this section are: "that no significant differences occur between the expressed levels of satisfaction of two selected samples of respondents with respect to their rated quality (adjudged assessments) of a given textbook illustration."

The lists of independent and dependent variables have been presented on page 83.

The repeated testing of the null-hypotheses for each dependent variable against the several pairs of independent variables has generated 960 individual null hypotheses. These are refuted at the $p = 0.05$ level of significance in 230 instances.

In order to streamline this chapter the 96 tables of t-test findings (tables 4.10 to 4.33) are attached in appendix 3. Note that the t-test assumes the existence of equal variances for the rating scores of two compared samples; but this assumption is not always satisfied for the 960 comparisons made by the Statistica programme. Consequently, the overall patterns of findings must be accepted with caution.

University of Cape Town

4.3 Overall summary of results for part C

The findings recorded in tables 4.10 to 4.33 have disclosed that different samples rate the illustrations significantly differently in many instances for the six different assessment criteria. Thus the following overall questions can be asked:

4.3.1 Who are more favourably disposed towards the illustrations, the disadvantaged learners or the advantaged learners?

The overall results are that in 164 instances the advantaged learners are more generous or favourable in their assessment; whereas in 76 instances the disadvantaged learners are more favourably disposed towards particular illustrations. This difference is statistically different (chi-square = 15.94; $p < 0.01$)

4.3.2 Who are more favourably disposed towards the illustrations, the disadvantaged learners or the teachers?

The overall results are that in 87 instances the disadvantaged learners are more favourable in their assessment; whereas in 33 instances the teachers are more favourably disposed towards certain illustrations. This difference is statistically different (chi-square = 11.87; $p < 0.01$)

University of Cape Town

4.3.3 Who are more favourably disposed towards the illustrations, the advantaged learners or the teachers?

The overall results are that in 99 instances the advantaged learners are more favourable in their assessment of particular illustrations; whereas in 19 instances the teachers are more favourably disposed towards individual illustrations. This difference is statistically different (chi-square = 29.13; $p < 0.01$)

4.3.4 Who are more favourably disposed towards the illustrations, the high school teachers or the primary school teachers?

The overall results are that in 32 instances the high school teachers are more favourable in their assessment; whereas in 26 instances the primary school teachers are more favourably disposed towards a given illustration. This difference is not statistically different (chi-square = 0.14; $p = 0.71$)

4.3.5 Who are more favourably disposed towards the illustrations, the Grade 8 learners or the Grade 9 learners?

The overall results are that in 132 instances the grade 8 learners are more favourable in their assessment; whereas in 94 instances the grade 9 learners are more favourably disposed towards certain illustrations. This difference is not statistically different (chi-square = 2.89; $p = 0.09$)

University of Cape Town

PART D: COMPARISONS BETWEEN THE YES/ NO RESPONSES OF THE TEXTBOOK ILLUSTRATIONS BY DIFFERENT SAMPLES OF RESPONDENTS

In this section the response frequencies are compared in pairs. The word 'Yes" refers to the belief that illustrations represent what they say they are, and the word "No" refers to the belief that illustrations do not represent what they say they are.

4.4 The disadvantaged science learners (N = 796) and the advantaged science learners (N = 788) with regard to the yes/ no responses

The hypothesis tested is " That there will be no significant differences between the responses of the 796 disadvantaged science learners and the 788 advantaged science learners in the frequencies of their yes/ no choices for each of the 17 selected illustrations."

The chi-square values recorded in table 4.34 (a-d) on pages 123 to 125 indicate that this hypothesis is refuted. Seven of the 17 illustrations yielded significant differences at the level $p < 0.01$ between the two groups. One of the illustrations yielded significant differences at the $p < 0.05$ level.

Reasons for the rejection of these seven significant illustrations have been mentioned above in section 4.2.

University of Cape Town

Table 4.34 (a) A frequency comparison of the yes/ no responses by the 190 disadvantaged science learners (N_a), and the 172 advantaged science learners (N_e).

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Yes	No	Yes	No		
Dinosaur	150	40	114	60	8.22	0.006 **
Lake	150	44	137	36	0.19	0.759
Squid hunting	113	83	130	42	13.13	0.0004 **
Water	162	33	125	45	4.93	0.0365 *
Shape of things	154	63	108	45	0.01	0.9705

* $p < 0.05$ shows significant differences between samples Na and Ne

** $p < 0.01$ shows highly significant differences between samples Na and Ne

Table 4.34 (b) A frequency comparison of the yes/ no responses by the 178 disadvantaged science learners (Nb), and the 237 advantaged science learners (Nf)

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Yes	No	Yes	No		
Lamp	147	55	195	38	7.67	0.008 **
Swarming Locust	134	40	185	49	0.25	0.7082
Perlemoen	78	94	145	85	12.47	0.0006 **

** $p < 0.01$ shows highly significant differences between samples Nb and Nf

University of Cape Town

Table 4.34 (c) A frequency comparison of the yes/ no responses by the 237 disadvantaged science learners (N_c), and the 166 advantaged science learners (Ng).

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Yes	No	Yes	No		
Gull flight	211	40	134	30	0.39	0.6223
Penguin	192	60	138	27	3.35	0.0879
Inside an egg	185	67	141	24	8.48	0.0053 **
Development of chick	182	70	146	18	16.82	0.0001 **

** $p < 0.01$ shows highly significant differences between samples Nc and Ng

University of Cape Town

Table 4.34 (d) A frequency comparison of the yes/ no responses by the 252 disadvantaged science learners (Nd), and the 200 advantaged science learners (Nh).

Response frequencies						
Item	Disadvantaged Learners		Advantaged Learners		Chi- square	p- value
	Yes	No	Yes	No		
Penguins in Peril	208	41	120	53	11.84	0.0009 **
Jackass penguin	195	55	141	31	0.99	0.3824
Hippos	128	121	84	91	0.48	0.554
Mussels	158	91	119	53	1.49	0.2652
Platannas	165	85	121	54	0.46	0.5655

** $p < 0.01$ shows highly significant differences between samples Nd and Nh

University of Cape Town

4.5 The high school teachers (N = 29) vs. the primary school teachers (N = 32) with regard to the yes/ no responses

The hypothesis is " That there will be no significant differences between the responses of the 29 high school teachers and the 32 primary school teachers in the frequencies of their yes/ no choices for each of the five selected illustrations."

The chi-square values recorded in table 4.35 on page 127 indicate that the hypotheses is refuted, for one of the five illustrations (platanna), which yielded a significant difference at the level $p < 0.01$ between the two groups, and another one of the illustrations (Jackass penguin) which yielded a significant difference at the $p < 0.05$ level.

Earlier, in section 4.2.50 on page 119, were presented some of the reasons supplied by the primary school teachers for their rejection of the drawing of the platanna.

University of Cape Town

Table 4.35 A frequency comparison of the yes/ no responses by the high school teachers (N = 29) and the primary school teachers (N = 32).

	Response frequencies					
Item	High school teachers		Primary school teachers		Chi- square	p- value
	Yes	No	Yes	No		
Penguins in Peril	28	1	26	6	3.51	0.1415
Jackass penguin	27	2	21	11	6.85	0.0212 *
Hippos	3	26	3	29	0.02	0.6156
Mussels	18	11	16	16	0.90	0.4904
Platannas	27	2	10	22	24.39	0.0000 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

4.6 The school teachers (N = 61) vs. the science learners (N = 1584) with regard to the yes/ no responses

The hypothesis tested is " That there will be no significant differences between the responses of the 61 school teachers and the 1584 science learners in the frequencies of their yes/ no choices for each of the five selected illustrations."

The chi-square values recorded in table 4.36 on page 129 indicate that the hypothesis is refuted. One of the five illustrations (hippos) yielded significant differences at the level $p < 0.01$ between the two groups.

University of Cape Town

Table 4.36 A frequency comparison of the yes/ no responses by the school teachers (N = 61) and the science learners (N = 1584).

Item	Response frequencies: School teachers Yes	School teachers No	Science learners Yes	Science learners No	Chi- square	p- value
Penguins in Peril	42	7	328	94	1.66	0.2688
Jackass penguin	48	13	326	86	0.01	0.9281
Hippos	6	55	212	212	34.76	0.0000 **
Mussels	34	27	277	144	2.35	0.1641
Platannas	37	24	286	139	1.05	0.3778

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

PART E: PRESENTATION OF THE FINDINGS WITH SPECIAL REFERENCE TO THE FLY; THE PERLEMOEN; THE INSIDE OF AN EGG AND THE DEVELOPMENT STAGES OF THE CHICK. (The auxiliary pictorial questionnaire)

This part of the results consists of four sections. In the first section the respondents were asked to identify two illustrations, namely the **fly** and the **perlemoen**. In the second section the respondents were asked to say, with reasons, whether a particular illustration represented an **egg**. They were also required to suggest improvements, if any, to the illustration. In the third section the respondents had to indicate, with reasons, whether two illustrations, namely the **fly** and the **perlemoen**, were well drawn or poorly drawn. In the fourth section the respondents were asked to write down the correct identification numbers of the labels next to the drawing numbers of the stages of the development of the **chick**. These illustrations have already been presented in chapter 3 (Appendix 2b and 2c).

University of Cape Town

Details of the samples of the volunteer respondent groups are summarized in table 4.37 on page 131.

Table 4.37 An overview/ summary description of the volunteer respondent groups for part E.

Group No.	Sample description	Sample size
1	Disadvantaged Grade 8 and 9	N = 270
2	Advantaged Grade 8 and 9	N = 160
3	All grade 8	N = 212
4	All grade 9	N = 218
5	All science learners	N = 430
6	High school teachers	N = 21
7	Primary school teachers	N = 34
8	All school teachers	N = 55

University of Cape Town

4.7. Identification of the two illustrations

80 % of the 427 learners correctly identified the illustration of the **fly**, whereas only 14.3 % correctly identified the illustration of the **perlemoen.**

4.7.1 The disadvantaged learners (N = 270) vs. the advantaged learners (N = 160)

The hypothesis states " That there is no significant difference between the responses of the 270 disadvantaged learners and the 160 advantaged science learners in the frequencies of their right and wrong answers for each of the two selected illustrations."

The Fisher values recorded in table 4.38 indicate that the null hypothesis is rejected

Table 4.38 A frequency comparison of the right/ wrong responses by the disadvantaged learners (N = 270) and the advantaged learners (N = 160) with respect to the illustrations of the fly and the perlemoen.

	Response frequencies					
Item	Disadvantaged learners		Advantaged learners		Chi-square or Fisher	p- value
	Right	Wrong	Right	Wrong		
Drawing 1 (fly)	228	42	148	12	5.94	0.0223 *
Drawing 2 (perlemoen)	1	270	60	100	114.16	0.0000 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

4.7.2 The Grade 8 learners (N = 212) vs. the Grade 9 learners (N = 218)

The hypothesis states " That there is no significant difference between the responses of the 212 grade 8 learners and the 218 grade 9 science learners in the frequencies of their right or wrong answers for each of the two selected illustrations."

The chi-square and Fisher values recorded in table 4.39 indicate that the null hypothesis is rejected for the **perlemoen**, but is tenable for the **fly**.

Table 4.39 A frequency comparison of the right/ wrong responses by the Grade 8 learners (N = 212) and the Grade 9 learners (N = 218) with respect to the illustrations of the **fly** and the **perlemoen.**

	Response frequencies					
Item	Grade 8 learners		Grade 9 learners		Fisher exact probability test	p- value
	Right	Wrong	Right	Wrong		
Drawing 1 (fly)	189	23	187	31	1.11	0.3633
Drawing 2 (perlemoen)	60	55	1	160	103.55	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

4.7.3 The high school teachers (N = 21) vs. the primary school teachers (N = 34)

All 55 teachers correctly identified the illustration of the **fly**, but ten of them failed to identify the **perlemoen.**

The hypothesis states " That there is no significant difference between the responses of the 21 high school teachers and the 34 primary school teachers in the frequencies of their right or wrong answers for each of the two illustrations."

The chi-square and Fisher values recorded in table 4.40 indicate that the null hypothesis is rejected for the **perlemoen**, but is tenable for the **fly**.

University of Cape Town

Table 4.40 A frequency comparison of the right/ wrong responses by the high school teachers (N = 21) and the primary school teachers (N = 34) with respect to the illustrations of the fly and the perlemoen.

	Response frequencies					
Item	High school teachers		Primary school teachers		Fisher exact probability test	p- value
	Right	Wrong	Right	Wrong		
Drawing 1 (fly)	21	0	34	0	-	-
Drawing 2 (perlemoen)	12	9	1	33	21.13	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2

4.7.4 The school teachers (N = 55) vs. the science learners (N = 430)

The hypothesis states " That there is no significant difference between the responses of the 55 school teachers and the 430 science learners in the frequencies of their right or wrong answers for each of the two illustrations."

The chi-square values recorded in table 4.41 indicate that the null hypothesis is rejected for the **fly**, but is tenable for the **perlemoen**.

Table 4.41 A frequency comparison of the right/ wrong responses by the school teachers (N = 55) and the science learners (N = 430) with respect to the illustrations of the **fly** and the **perlemoen.**

	Response frequencies					
Item	School teachers		Science learners		Chi- square	p- value
	Right	Wrong	Right	Wrong		
Drawing 1 (fly)	55	0	376	54	7.77	0.0105 *
Drawing 2 (perlemoen)	13	42	61	370	3.40	0.1001

* $p < 0.05$ shows significant differences between samples 1 and 2

University of Cape Town

4.8 The correct identification of the drawing of the egg

All the respondents, namely learners (advantaged and disadvantaged) as well as the teachers (high school and primary school), could identify the illustration of the **egg** correctly. The reason it is an egg, supplied by the respondents, was in all cases the shape of the illustration.

4.8.1 Suggestions for improvements to the illustration of the egg

All the respondents indicated no problem with the position of certain parts in the egg illustration; nor with the accuracy of the labels; nor with the shape of the drawing. However, the colour of each part, as well as the size of the embryo was problematic for about 80% of the respondents. With regard to the colour, the responses included "the illustration should be more colourful"; "the embryo should be brown"; "the yolk should be yellowish to orange"; and "the shell should be grey to white". With regard to the size of the embryo, the respondents indicated that "the embryo should be bigger."

University of Cape Town

4.9 Indications whether the illustrations are well drawn or poorly drawn

79.4 % of the 427 learners considered the illustration of the **fly** to be drawn well. However, only 29.5 % considered the **perlemoen** to be drawn well.

4.9.1 The 270 disadvantaged learners vs. the 160 advantaged learners

The hypothesis states " That there is no significant difference between the responses of the 270 disadvantaged learners and the 160 advantaged science learners in the frequencies of the well drawn/ poorly drawn assessments for each of the two illustrations, namely the **fly** and the **perlemoen**."

The chi-square values recorded in table 4.42 indicate that the null hypothesis is rejected.

Table 4.42 A frequency comparison of the well drawn/ poorly drawn assessments by the disadvantaged learners (N = 270) and the advantaged learners (N = 160).

	Response frequencies					
Item	Disadvantaged learners		Advantaged learners		Chi- square	p- value
	Well Drawn	Poorly drawn	Well drawn	Poorly drawn		
Drawing 1 (fly)	257	10	136	24	17.29	0.00000 **
Drawing 2 (perlemoen)	67	197	59	99	6.75	0.0128 *

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

4.9.2 The 212 Grade 8 learners vs. the 218 Grade 9 learners

The hypothesis states " That there is no significant difference between the responses of the 212 Grade 8 learners and the 218 Grade 9 science learners in the frequencies of the well drawn/ poorly drawn assessments for each of the two illustrations, namely the **fly** and the **perlemoen**."

The chi-square values recorded in table 4.43 indicate that the null hypothesis is rejected for the **fly**, but not for the **perlemoen**.

Table 4.43 A frequency comparison of the well drawn/ poorly drawn responses by the Grade 8 learners (N = 212) and the Grade 9 learners (N = 218).

	Response frequencies					
Item	Grade 8 learners		Grade 9 learners		Chi- square	p- value
	Well Drawn	Poorly drawn	Well drawn	Poorly drawn		
Drawing 1 (fly)	200	9	193	25	7.47	0.0107 *
Drawing 2 (perlemoen)	71	138	55	158	3.35	0.0850

* $p < 0.05$ shows significant differences between samples 1 and 2

University of Cape Town

4.9.3 The 21 high school teachers vs. the 34 primary school teachers

The hypothesis states " That there is no significant difference between the responses of the 21 high school teachers and the 34 primary school teachers in the frequencies of the well drawn/ poorly drawn assessments for each of the two illustrations, namely the **fly** and the **perlemoen**."

The Fisher values recorded in table 4.44 indicate that the null hypothesis is tenable.

Table 4.44 A frequency comparison of the well drawn/ poorly drawn responses by the High school teachers (N = 21) and the primary school teachers (N = 34).

	Response frequencies					
Item	High school teachers		Primary school Teachers		Fisher exact probability test	p- value
	Well drawn	Poorly drawn	Well drawn	Poorly drawn		
Drawing 1 (fly)	15	3	29	5	0.03	0.5738
Drawing 2 (perlemoen)	1	21	1	33	0.10	0.6357

University of Cape Town

4.9.4 The 55 school teachers vs. the 430 learners

The hypothesis states " That there is no significant difference between the responses of the 55 school teachers and the 430 learners in the frequencies of the well drawn/ poorly drawn assessments for each of the two illustrations, namely the **fly** and the **perlemoen**."

The Fisher values recorded in table 4.45 indicate that the null hypothesis is rejected for the **perlemoen**, but supported for the **fly**.

Table 4.45 A frequency comparison of the well drawn/ poorly drawn responses by the school teachers (N = 55) and the learners (N = 430).

	Response frequencies					
Item	School teachers		Science learners		Fisher exact probability test	p- value
	Well Drawn	Poorly drawn	Well drawn	Poorly drawn		
Drawing 1 (fly)	47	8	393	34	2.65	0.1691
Drawing 2 (perlemoen)	1	54	126	296	19.58	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

4.10 The correct labels next to the drawing numbers

4.10.1 The disadvantaged learners

a) Grade 8 (N = 126): Only two learners had the correct labels next to all the drawing numbers. However, if indicating the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 40 learners but they were wrong.

ii) The second label was marked as "correct" by 18 learners but they were wrong.

iii) The third label was marked as "correct" by 50 learners but they were wrong.

iv) The fourth label was marked as "correct" by 42 learners but they were wrong.

v) The fifth label was marked as "correct" by 17 learners but they were wrong.

b) Grade 9 (N = 144): Twenty learners had the correct labels next to the drawing numbers. However, if the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 76 learners but they were wrong.

ii) The second label was marked as "correct" by 39 learners but they were wrong.

iii) The third label was marked as "correct" by 86 learners but they were wrong.

iv) The fourth label was marked as "correct" by 79 learners but they were wrong.

v) The fifth label was marked as "correct" by 31 learners but they were wrong.

University of Cape Town

4.10.2 The advantaged learners

a) Grade 8 (N = 86): Seventeen learners had the correct labels next to the drawing numbers. However, if indicating the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 63 learners but they were wrong.

ii) The second label was marked as "correct" 32 learners but they were wrong.

iii) The third label was marked as "correct" by 60 learners but they were wrong.

iv) The fourth label was marked as "correct" by 53 learners but they were wrong.

v) The fifth label was marked as "correct" by 26 learners but they were wrong.

b) Grade 9 (N = 74): Ten learners had the correct labels next to the drawing numbers. however, if indicating the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 62 learners but they were wrong.

ii) The second label was marked as "correct" by 15 learners but they were wrong.

iii) The third label was marked as "correct" by 52 learners but they were wrong.

iv) The fourth label was marked as "correct" by 51 learners but they were wrong.

v) The fifth label was marked as "correct" by 17 learners but they were wrong.

University of Cape Town

4.10.3 The school teachers

a) The primary school teachers (N = 34): Seventeen teachers had the correct labels next to the drawing numbers. However, if indicating the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 26 teachers but they were wrong.

ii) The second label was marked as "correct" by 25 teachers but they were wrong.

iii) The third label was marked as "correct" by 27 teachers but they were wrong.

iv) The fourth label was marked as "correct" by 28 teachers but they were wrong.

v) The fifth label was marked as "correct" by 20 teachers but they were wrong.

b) The high school teachers (N = 21): Eleven teachers had the correct labels next to the drawing numbers. However, if indicating the correct label was considered step by step, the following emerged:

i) The first label was marked as "correct" by 15 teachers but they were wrong.

ii) The second label was marked as "correct" by 13 teachers but they were wrong.

iii) The third label was marked as "correct" by 20 teachers but they were wrong.

iv) The fourth label was marked as "correct" by 20 teachers but they were wrong.

v) The fifth label was marked as "correct" by 14 teachers but they were wrong.

University of Cape Town

4.11 Chapter summary

This chapter was divided into five major parts. In part A it was found that the inter-correlations between the ratings made by the various groups of assessors yielded correlations ranging from 0.70 to 0.93. This evidence suggests that confidence could be placed in the overall honesty, trustworthiness and reliability of the assessors who took part in the evaluation.

Next, all forty illustrations are presented with their overall impression ratings by learners and teachers, and the respondents' qualitative justifications and explanations are presented. Then the overall hypotheses are tested and analysed, using t-tests. Further hypotheses are then tested in the agree/ disagree responses.

Finally the findings with reference to the fly and perlemoen; inside of an egg; and development stages of the chick are presented.

A discussion of these findings occurs in **Chapter 5.**

University of Cape Town

CHAPTER 5

DISCUSSION OF RESULTS

University of Cape Town

CHAPTER 5

DISCUSSION OF RESULTS

In this chapter a discussion of the findings will follow the approximate order of the main themes of the literature review presented in chapter 2. Firstly, the importance of illustrations and the reasons for including them in science textbooks will be mentioned briefly, but with the evidence and results from chapter 4 being cited to support, modify, change or add to this existing literature.

Secondly, the strengths and weaknesses of the several different types of science textbook illustrations will be discussed in the light of the qualitative findings presented in the previous chapter.

Thirdly, an analysis will be made of the common local and general problems that are encountered in the learning of illustrations, in the light of the respondents' evaluatory assessments, as presented in the previous chapter.

Fourthly, the factors which appear to affect the accurate interpretation of illustrations will be explained and discussed in the light of the evidence presented in chapter 4.

Finally, the implications of this discussion for the particular textbook *New Nation Science Grade 7 (1999)* will be elucidated.

University of Cape Town

5.1 A discussion of the importance of illustrations and reasons for including them in textbooks

Duchastel (1980), cited in Rowe (1990: 30), " developed, according to function, a three-category model for illustrations: **attentional, explicative** and **retentional.**" The attentional illustration is one whose main purpose is to keep the reader interested in the text.

The responses of the learners in Cape Town support the claims of Duchastel because about 20 % wrote comments verbatim such as: "It is very clear, it catches your eyes fast"(sic); "It drawed my attention very quickly because it is colourful and gives a lot of information"(sic); "It catches my attention with the colour and there is lot of interesting information"; "Because the colour is bright and beautiful, it caught my attention"; and "It attracts my attention because the colour is bright." (Thesis page numbers 91, 96, 97 and 102).

University of Cape Town

Levin (1987) divided the functions of illustrations into five broad categories, namely, **decorative, representational, organizational, interpretational** and **transformational.** The decorative function helps the reader to enjoy the textbook and make it more attractive.

Attraction is also a frequently presented reaction from respondents; for example, "The picture is excellent and there is lots of colour"; " "It is full of colour and pretty"; and

" The drawings were great, the colour made the drawing understandable and it looks beautiful." (Thesis page numbers 89, 94 and 100).

Brody (1982), cited in Peeck (1993: 227), indicated that "in addition to their traditional decorative role, pictures can excite the learner, explain difficult concepts and expand the narrative."

The evidence supplied by the South African samples of respondents supported this claim since more than 30 % commented: "It is a clear drawing and the entire water cycle can be seen"; "The drawing style and picture is clear - it is easy to see what is happening in the picture"; "It tells you everything you want to know. The picture is very clear"; and so on. (Thesis page numbers 104 and 105)

University of Cape Town

5.2 Types of illustrations

According to Ramsey (1989: 46), "Artistic style, the mode used by an artist, has an influence on children's picture preferences, and varies from the highly realistic to highly abstract representations." Researchers have investigated children's picture preferences and concluded that children preferred realism in pictures (Myatt and Carter, 1979; Ramsey, 1982), cited in Ramsey (1989: 46). According to Kearsey and Turner (1999: 93) " 14 –16 year old pupils want clear diagrams, and find the diagrams more useful than photographs."

The responses of the respondents in Cape Town support the claims of Ramsey as well as Kearsey and Turner because they wrote comments such as "The picture looks good, like the real thing"; "It is not realistic because the sun is shining in the house"; "It was very accurate"; "It is colourful and looks like the real bird"; "The picture is very clear and it looks like it's real"; "They are like that on TV"; "It look almost real"; and so on. (Thesis pages numbers 89, 91, 93, 99, 100 and 104).

On the other hand, according to Kearsey and Turner (1999: 93), teachers like to see good photographs. This was also a frequently presented response from respondents; for example, " A poor representation – one is going to the trouble of colour pictures, why not a photograph?" (Thesis page number 108).

University of Cape Town

5.3 Problems encountered with the learning of illustrations

5.3.1 Diagram interpretation

According to Kearsey and Turner (1999: 87)

> "The ability of pupils to interpret figures depends on their prior experiences, and hence previous exposure to science textbooks. Prior experience could therefore play an important role in the contribution which figures makes to the understanding of pupils from ethnic minority groups. These students might have difficulty interpreting drawings."

The responses of the respondents support the claims of Kearsey and Turner because about 40 % of the Xhosa-speaking respondents wrote comments about the animals such as: "I don't like them, they are very scary"; "Not for me, but for the white people

to eat"; "I don't like a penguin because it is very dirty"; I can't see the picture clearly, but I know one thing: hippos is very dangerous to us so we don't need them in our country"; "Because big rain destroy our homes sometimes. My mother boiled water before we drink it"; "I don't know what a mussel is. I think it is a fruit produced in South Africa"; "I don't like this animal because it looks like a witch and I sked of sorry animal. I don't like you "(sic); and so on. [Appendix (4) pages 1, 2, 3, 4, 5, 6 and 7].

My own interpretation of the respondent samples' comments occurs against the variations in context or local conditions of the present study. It is obvious that the Xhosa–speaking learners may not have interacted with illustrations from an early age. Consequently they may lack understanding of the intended detail and will therefore relate these illustrations to their particular context. Therefore they might look at an illustration and make up their own story to understand a particular picture or drawing, irrespective of the context in which a particular illustration has been used.

A typical example is the illustration of **days of big rain** on textbook page 145. The Xhosa-speaking learners all talk about water being used for cooking or washing and how water affects their daily lives from their own personal experiences.

Most of the illustrations are judged from a personal point of view; for example, "I don't like the illustration of the **platannas** because I don't like platannas". The

University of Cape Town

illustration can be clear, colourful, etc., but because they do not like a specific object, they do not like the particular illustration of that object.

In my view, I think that some of these learners might only glance at the illustration, do not attempt to have a deeper understanding of a particular illustration; and do not use the illustration effectively because they do not understand it.

5.3.2 Perceptual problems

According to Constable *et al.* (1988: 90), " A dependence upon familiarity with the pictorial conventions employed is important to understanding the illustration". Therefore, according to Constable, "certain pictures are more difficult to interpret than others because they use more pictorial conventions (such as artist depth cues), and these are often not understood by the viewer" (page 90). Furthermore, "If a learner does not understand the conventions, he may use a dimly understood view of what the object may be, to decipher the conventions".

University of Cape Town

The evidence supplied by samples of the Cape Town learners supports this claim because they wrote comments such as, "You don't understand what is going on and it does not say what squid hunting is"; "It is unclear and has little colour"; "The picture has no labels and a person won't understand it"; "You can hardly make out what is going on and it is not clear enough"; "I could not make out what it was and the colour was not nice";

"I really cannot make out if it's a chicken or not"; and so on (Thesis pages 92, 93, 96, 98 and 100).

In the identification of the illustrations of the **fly** and the **perlemoen**, 88 % of the 427 learners correctly identified the illustration of the fly, whereas only 14 % correctly identified the illustration of the perlemoen. It can be concluded that the learners may have had a dim view of what the illustration of the perlemoen may have been, because they wrote comments such as it depicting "a man holding a torch"; "A hand with branches"; "Fire"; "Shell"; and so on.

On the other hand, the teachers fared no better with the correct identification of the illustrations of the fly and the perlemoen. Although everyone could identify the illustration of the fly, only 24 % of the 55 teachers could correctly identify the illustration of the perlemoen. Therefore the teachers also had difficulty in interpreting and understanding the illustration of the perlemoen, and wrote comments such as it depicting "A fire"; "Torch bearer"; "Man holding assegai"; and so on.

University of Cape Town

5.3.3 Learners' problems with graphics

According to Lowe (1993: 158), "Unless the student comprehends the diagram, and does so in a manner that is consistent with the authors' intentions, the facilitative effects of diagrams are unlikely to occur". Gerber (1995: 79) also demonstrated that learners experienced a wide range of difficulties in understanding graphics. However,

5.4 Factors which may affect accurate interpretation of illustrations

5.4.1 The colour of the illustration

According to Reid (1984: 30) research on colour illustration as opposed to black and white is ambiguous. Dwyer (1972), cited in Rowe (1990: 27) "investigated an illustrated sequence on the topic of the heart using a variety of graphic media, and his analysis revealed that students preferred colour in diagrams".

According to Holliday (1990: 28)

> "Colour is useful when employed to highlight or discriminate important pieces of visual information. The use of colour does not necessarily change student attitudes towards science or motivate them."

In a study of the heart, Reid *et al* (1983: 327), " found that colour was irrelevant to pupils' scores in an objective items recognition test. However, Holliday (1973), cited in Reid (1984: 30), felt that " the fact that students prefer colour to black and white is no predictor of its effectiveness". According to Carter (1984), cited in Reid (1984: 30), colour was "beneficial in perceptual rather than conceptual tasks".

University of Cape Town

In Cape Town the colour of the illustrations was an aspect frequently mentioned by the respondents because about 90 % wrote comments such as "The colour is too poor"; "I feel that more colour should have been supplied"; "The picture is very colourful"; Because the colour is bright and beautiful it caught my attention"; "The colour of the picture is dull"; "The colour is bright and it explains everything they are saying"; "It looks beautiful and colourful"; "It was very attractive because of the

bright colours, and it was easy to make out"; "The drawing was understandable but the colour was dull"; "It was a nice picture but there is no colour in it"; and so on. (Thesis pages numbers 89, 90, 92, 93, 99, 100, 101 and 104).

What also emerged was the finding that the younger grade 8 learners were more satisfied with the colour of the illustrations, rating it higher in 26 out of 40 illustrations (65 %). The older grade 9 learners rated it higher in 14 of the 40 illustrations (35 %). The learners were also more satisfied than the teachers on their colour rating for the 10 illustrations (100 %).

This finding agrees with those of Machotka (1966), cited in O'Hare and Cook (1983: 269), who "found colour to be the most frequently mentioned justification for choice by children from age 6 upwards".

University of Cape Town

5.4.2 The size of the illustrations

Another question that needs to be asked is: Does the size of the illustration make a difference?

According to Holliday (1990: 28), "Children can visually discriminate just as well as adults. As a rule children have no problem understanding the kinds of visuals used in science texts designed for older readers". Dwyer (1972), cited in Kearsey and Turner (1999), agreed that "the size of the pictures had little effect on learning".

However, in Cape Town, for the textbook *New Nation Science Grade 7*, more than 60 % of the respondents expressed dissatisfaction with the size of the illustrations, and wrote comments such as, "It is too small, too little detail and does not explain enough"; "The picture is too small and not enough labels'; "The sketch is fine but they could have made it bigger and have more information"; "The picture is not clear enough and the size is too small"; "The drawing is small and gives us no labels of the spider"; "The drawing is too small and does little to explain a particular concept"; and so on. (Thesis pages 89, 91, 93, 94, 98 and 105).

5.4.3 The labels/ information

Diagrams and pictorial representation do tend to reinforce learning and make reading interesting (Ghebru, 2001: 20). However, for diagrams to have instructional value they must be labelled properly. Soyibo (1996: 192) points out that labelled diagrams are essential memory guides. Unlabelled diagrams, on the other hand, are undesirable, especially on topics involving structure and function, and have no instructional value for the young reader.

For the textbook *New Nation Science Grade 7*, criticism was frequently made of unlabelled diagrams with no information supplied because the respondents wrote comments such as, "There was no labels"; "It must get more labels and colour to tell you more about the picture"; "Too little information provided"; "The labels is very

University of Cape Town

clear so it makes it easy to understand"; "Little information is supplied"; "Only questions are asked"; and so on. (Thesis pages 89, 90, 91 and 101).

In the instruction where the correct label number had to be placed next to the correct drawing number, only 11.5 % of the 427 learners had the correct labels next to all the drawing numbers, whereas 52.7 % of the teachers had the correct labels next to all the drawing numbers. This finding discloses that, for illustrations to have instructional value and be fully understood, they must be properly labelled. In my view, the fact that the teachers did not perform well in this section of the questionnaire may be because the exercise was not so well understood by all the respondents.

University of Cape Town

5.4.4 Age

Wu (1977), cited in Reid (1984: 30), found that "age was relevant up to about nine years, but that adults generally remembered pictures as 9–year olds". The inter group correlations presented in table 4.3 on page 89 show that all the inter-correlations are high and significant and therefore agree with the findings of Wu.

However, according to Mendler and Robinson (1978), cited in Reid (1984: 30), "The type of picture which is best remembered may vary with age. Children generally performed as well as adults on familiar pictures, but not with unfamiliar or unstructured ones".

Table 4.2 on page 87 discloses that the teachers gave higher ratings than the learners on the illustrations of **water cycle, penguins, kelp gull feeding** and **platannas**, which were unfamiliar to the learners. Many of the learners appeared not to understand these illustrations because they wrote comments such as "The penguin is standing on dry land'; "The penguins need to be in a cool/ cold area'; and so on.

5.4.5 Relevance to the text

Kearsey and Turner (1999:88) indicated that it had been shown that figures included in textbooks tended to help in the explanation and understanding of the written text. According to Ogunniyi (1982), cited in Ghebru (2000: 20), "Pictures, diagrams and graphs, through form and colour, can complement words and add clarity to the given discussion". Care must be taken to ensure that the visual materials do not create additional learning difficulties (Ghebru, 2000: 20). Clarke (1997), cited in Ghebru (2000:20), suggested, "that not only must the illustration be carefully integrated into the text, but also that the students must learn to read and interpret pictures".

Reid (1990 b) came to the conclusion that only those pictures which contained information which was included in the text, enhanced learning. Reid and Beveridge (1986) also concluded that, for illustrations to have a beneficial effect, there should be references to them in the accompanying text.

University of Cape Town

The evidence supplied by the Cape Town respondents agrees with the observations of Reid and Beveridge because they made statements such as "I like the picture because of the colour. It really captured my eyes and is also relevant to the text"; "It shows a good explanation of what you are talking about"; "There is not a lot of information and its text wasn't precise and to the point'; "Even though the drawing is all right, there is no relevance to the text"; and so on. (Thesis pages 90, 93, 96, 102 and 103)

In my view, because the advantaged groups consistently rated each drawing higher in terms of "relevance" than the disadvantaged group, it is possible that the word "relevance" was less well understood by the disadvantaged learners.

5.5 Discussion with regard to textbook illustrations

It is important to understand how the learners encounter, understand and use graphics in their lives. The social and/ or cultural context in which experiences occur will influence the way that these experiences are reported and interpreted (Gerber *et al.*, 1995: 78).

Many theories have been developed over the last decades to explain how learners interpret and understand graphics. These have been briefly discussed in a previous chapter. They include Paivios dual coding theory; Kulhavy's theory of conjoint processing; mental models that produce analog mental representations; concept of

University of Cape Town

structure mapping; and Schnotz's investigation on how successful learners differ from unsuccessful learners in their processing of texts and graphics.

The postulates of these theories may be useful, but they do not take into consideration the mutuality of people and their social-cultural environment. According to Gerber *et al.* (1995: 78), there exists a relationship between the individual and social and cultural environment where none exists separately. Therefore studies in human awareness, need to be investigated in close relation to their contextual settings; for example, perception and understanding of illustrations.

In the South African context this is quite important. Although numerous research findings regarding disadvantaged learners and how they understand and interpret illustrations have been published, very few studies have been reported from a South African disadvantaged learners' view.

University of Cape Town

In South Africa we have a cycle of under-preparedness where learners are taught by inadequately and improperly trained teachers, who lack a proper understanding of, for example illustrations. These learners later qualify as teachers and may then display the same characteristics as their teachers.

As an experienced educator of many years, having taught at both advantaged and disadvantaged schools, it is my view that this is a phenomenon which will take a few

years to rectify because many teachers still do not understand diagrams and illustrations themselves.

Attending workshops to assist teachers with experimental work, I was surprised by the number of teachers who could not perform the textbook-based experiments. If a teacher has not experienced microscopic observations of specimens, for example, they would not be able to know whether the textbook illustration is correct. For instance, how many teachers have seen specimens such as the *Amoeba* species under the microscope? These same teachers teach the illustration of the *Amoeba* species, using the textbook illustration. If the textbook illustration is wrong, these teachers won't know, and consequently the learners will study the incorrect illustration.

Teachers play an important role ensuring that misconceptions do not arise with incorrect textbook illustrations. Any mistakes in a textbook illustration should be immediately brought to the attention of the learners. Consequently, it is important that the teachers themselves must have an understanding of the illustration.

There should also be closer co-operation between the publishers, teachers and learners. The publishers must be made aware of the problems that learners encounter with the textbooks, and mistakes in the text and illustrations. It is frustrating for the teacher if there are mistakes in the textbook. The learners don't believe the teacher when these mistakes are rectified because, according to them, if it is in a book, then it

University of Cape Town

must be correct. However, if a teacher does nothing about these mistakes, and meekly accepts them, he/ she will only compound the problem of misperceptions.

5.6 Implication of this discussion for the textbook *New Nation Science Grade 7(1999)*

According to Holliday (1990: 28), "Publishers determine the quality, quantity, placement, size, colour and relevance of the visual aids to the texts". Visuals are perceived by the publishers to increase the understanding of the texts whilst reducing the readability load on the learners.

In the study of the learners' perceptions and ratings of the illustrations in the textbook *New Nation Science Grade 7 (1999)*, a number of significant findings have emerged. Firstly, although there are significant differences amongst the groups, the learners are almost certainly expressing how they feel about the illustrations honestly.
Secondly, about 90 % of the respondents expressed dissatisfaction with the **lack** of **labels** in more than 90 % of the illustrations. This is problematic, because the learners apparently expect an illustration to have labels or some information that will assist with the understanding of the illustration, which was also highlighted earlier.

Thirdly, another problem area for the learners was the **size** of the illustrations. According to the respondents, about 60 % of the illustrations are **too small**. Although

University of Cape Town

the literature indicated that the size of the illustration does not matter, the respondents from Cape Town feel that the size of the illustration is important for the understanding of the illustration, for example **asteroid** (page 25); **days of big rain** (page 145); and so on.

Fourthly, all respondents had a problem understanding certain illustrations, for example **perlemoen** (page 13); **chicken** (page 100); **days of big rain** (page 145); and **hippos** (page 157). It is hoped that these illustrations will be reconsidered, so that better understandable illustrations can be included in future editions of the textbook.

Finally, the publishers should be aware that there is a difference in perception and ratings of illustrations between the urban advantaged learner, who has been immersed in illustrations from an early age, and the rural disadvantaged learner who has not been exposed to illustrations. Although the literature indicates that it is not necessary to cater for the disadvantaged learners, in my view, as an experienced educator who has been teaching to Xhosa-speaking learners for a number of years, and seeing how they struggle with the illustrations, it is important that the publishers must investigate this problem.

University of Cape Town

5.7 Chapter summary

A discussion of both empirical and qualitative results reported in **chapter 4** has been presented in this chapter. The importance of illustrations; types of illustrations;

problems encountered in the learning of illustrations; and the factors which affect the interpretation of illustrations have been presented, but using the qualitative findings presented by the respondents to support, add, change or modify the existing literature. The implication of this discussion for the textbook *New Nation Science Grade 7 (1999)* have also been presented.

Chapter 6 will now draw conclusions, and recommendations will be made for further research.

University of Cape Town

CHAPTER 6

RECOMMENDATIONS

&

CONCLUSIONS

University of Cape Town

CHAPTER 6

IMPLICATIONS, RECOMMENDATIONS AND CONCLUSIONS

This chapter presents six implications for more effective classroom teaching illustrations in science textbooks, six recommendations, and draws several conclusions.

6.1 Implications for effective teaching of illustrations in classrooms

Implication 1

Teachers might **evaluate** the illustration **content** when a new textbook is introduced to learners. As an experienced teacher who is normally consulted, I know and realize that teachers normally have no say in the acquisition of the type of textbook which will be utilised by the learners. However, teachers must be invited to **form opinions** on how particularly good or poor sections of the textbook are, and **inform** the authors/ publishers. This is especially important when considering the illustrations in the textbook.

University of Cape Town

Implication 2

Learners might be afforded the opportunity to **construct** their **own diagrams** during an investigation or when they carry out practical work. These illustrations can then be

compared with the illustrations in the textbook. Therefore the learners could be given opportunities to discover things on their own, and the role of the teachers is to **coach** the learners in constructing their own diagrams.

Implication 3

The teachers must not always assume that the learners will **understand** the textbook illustrations. Merely telling learners that they must study an illustration is insufficient. The learners must be **encouraged** to study the illustrations in a text. This might be achieved by some form of instructional **intervention,** such as supplying the learners with illustrations without labels, and the labels might then be added by using the textbook.

Implication 4

Learners can be **taught** how to relate to the illustrations in a more focused way. The illustrations should not be seen as adjuncts to the predominant text, but can be used as a source of information in their own right. If an illustration has a few cues, the knowledgeable teacher might have to **guide** the learners by adding more questions to **direct** the learners through the text illustrations.

University of Cape Town

Implication 5

If some teachers rarely explain the **educational functions** of illustrations, and if they allow little instructional time for the illustrations, then they might become more **prescriptive** in the way they expect the learners to treat illustrations.

Implication 6

Learners do not always have to be supplied with the ready-made pictorial material. Teachers might require that the learners produce pictures, or parts of pictures themselves. Instructor-created illustrations can also be developed in the classroom. Such learner-produced illustrations of the text might be important for a deeper understanding of the illustrations, because very few learners try to build visuals aids of their own as they read.

University of Cape Town

6.2 Recommendations for effective teaching of illustrations

Recommendation 1

In school science and biology there could be a promotion of a higher level of visual literacy, which clearly presupposes an ability to teach the literal pictorial content, to

enable learners to see beyond the representational qualities of the text illustrations and advance to what they can identify as the intended meaning.

Recommendation 2

The promotion among learners of high levels of scientific visual literacy might be achieved by focusing on illustrations that is well-labelled.

Recommendation 3

Before publishers release science textbooks with illustrations, it is recommended that the publishers consult a wide cross section of potential users to comment specifically on the suitability of various qualities of the illustrations, such as their colour, size, quality of labeling, and so on.

University of Cape Town

6.3 Recommendations to the publishers for better understood illustrations by the learners

Recommendation 1

It may be useful if publishers are made aware that users' prior knowledge and experience with the subject matter of the illustrated text may significantly affect responses to, and understanding of the illustrations. Therefore the contextual visual

needs and the abilities of the learners, related to the varied levels of visual literacies and cultural backgrounds among the learners, must be considered by the publishers.

Recommendation 2

Illustrators and editors of the text analyzed in this study should be given education in visual literacy, so that the style of illustrations can be more appropriate to a diversity of users.

Recommendation 3

It might be of the assistance to publishers if they are aware of how the learners actually use the illustrations during their studies. Therefore there could be closer co-operation between the teachers, learners and the publishers. If the textbook illustrations are to serve the goals of education, the publishing companies, researchers and educators must be invited to work more closely together.

University of Cape Town

6.4 Recommendations for future research

The research in the understanding and interpretation of illustrations has broadened over the last decade, and a clearer picture is emerging. However, in most of these research studies, the contextual settings were not considered. This is particularly important in our South African context. The relationship between the individual, the

social and the cultural environment must be considered, because none of them exist separately. The conceptual difficulties and a wide range of personal factors reduce the effectiveness of each learner to derive meaning from the illustrations.

When researchers investigate the understanding and interpretation of illustrations, to date Western criteria have been used. What is envisaged is that a set of criteria be developed, which will suit our diverse cultural society, and which may possibly account for the gap in understanding by the disadvantaged South African learners reported when only first world criteria are used as benchmarks.

In a similar manner, an investigation could be made of how South African teachers view illustrations; and how the illustration might influence their teaching behaviour. Are the illustrations effectively used, or are the learners merely asked to copy the illustrations in their notebooks? On numerous occasions I have seen learners in public libraries photocopying illustrations to be pasted in their notebooks. Research needs to be done to find out how South African teachers use illustrations.

University of Cape Town

6.5 Conclusions

For the Cape Town teachers the textbook is the most identifiable educational tool. Because the textbook has over the years become more pictorial, and illustrations are assuming a more important role, this study set out to answer four major questions as set on page 8.

The publishers of school textbooks usually determine the quality as well as the quantity of visual aid. The question that needs to be asked is: Do the learners understand the illustration in the same way as the teachers? Furthermore, is there a difference between the perception of the illustration by some groups of the disadvantaged learners and some groups of the advantaged learners?

This study has revealed, firstly, that the publishers must not assume that all visual aids may be clear to all the learners. It has been shown that the context of the learner is related to the perception/ misperception of the illustration; for instance the disadvantaged learners tend to prefer certain types of illustrations and that some may interpret the illustrations from a personal point of view.

Secondly, criteria such as colour, size, labels, and so on must be considered, in at least some of our South African contexts, and must not be measured against Western criteria.

What is still not clear, and further research needs to be done, is how do our South African learners, especially the rural learners interpret, use and understand the illustrations. This study has shown that prior knowledge may play an important role in responses to the understanding of the illustrations. Therefore, publishers and authors of school textbooks must be made aware of research findings, so that improved illustrations can be included in the school textbooks through feedback from the users.

University of Cape Town

References

1. Amsden, R (1960). Children's preferences in picture story book variables. *Journal of Educational Research*, 53: pp 309-312.
2. Anderson, G (1990). Fundamentals of Educational Research. Burgess Science Press: Great Britain.
3. Babbie, E.R (1973). Survey Research Methods. Washworth Publishing Company: California.
4. Bergerud, D, Lovitt,T and Horton, S (1988). The effectiveness of textbook adaptations in life science for high school students with learning disabilities. *Journal of learning Disabilities*, 21 (2) February: pp 70-76.
5. Blystone, R and Deltling, B (1990). Visual Literacy in Science Textbooks. In. Rowe, M (Eds.), What Research Says To the Science Teacher, pp 19-40. National Science Teachers Association.
6. Brooks, M, Glenn, S and Crozier, W (1988). Pre-school children's preferences for drawings of a similar complexity to their own. *British Journal of Educational Psychology*, 58 (2): pp 165-171.
7. Buckley, B (2000). Interactive multimedia and model-based learning in biology. *International Journal of Science Education*, 22 (9): pp 895-935.
8. Burns, R. B (1997). Introduction to Research Methods. University of Brunei
9. Cohen, L (1976). Educational Research in Classrooms and Schools: A Manual of Material and Methods. Harper and Rowe Publishers: London.
10. Cohen, L and Manion, L (1990). Research Methods in Education. Biddles: Great Britain.

University of Cape Town

11. Cohen, L and Manion, L (1985). Research Methods in Education. Croon Helm: London.

12. Constable, H, Campbell, B and Brown, R (1988). Sectional drawings from science textbooks: an experimental investigation into pupils' understanding. *British Journal of Educational Psychology,* 58: pp 89-102.

13. Delamont, S (1992). Fieldwork in Educational Settings: Methods, Pittfalls and Perspectives. The Falmer Press: London

14. Department of Education Policy Document: Natural Science Intermediate Phase. (October 1997).

15. Donald, D (1981). The role of illustrations in children's oral reading accuracy, strategies and comprehension at different developmental and progress levels: a psycholinguistic investigation. Unpublished Ph D thesis, University of Cape Town.

16. Donald, D (1983). The use and value of illustrations as contextual information for readers at different progress and developmental levels. *British Journal of Educational Psychology,* 53: pp 175-185.

17. Dondis, D (1984). A Primer of Visual Literacy. MIT Press: Cambridge Massachusetts.

18. Dove, J, Everett, L and Preece, P (1999). Explaining a hydrological concept through children's drawings. *International Journal of Science Education,* 21 (5): pp 485-497.

University of Cape Town

19. Dwyer, F.M. (1994). One Dimension of Visual Research. A Paradigm and Its Implementation. In Moore, D.M and Dwyer, F.M. (Eds.) (1994) Visual Literacy: A Spectrum of Visual Learning, pp 383-401. Educational Technology Publications: New Jersey.

20. Evans, M, Watson, C and Willows, D (1987). A Naturalistic Inquiry into Illustrations in Instructional Textbooks. In Willows, D and Houghton, A (Eds.) (1994) The Psychology of Illustration: Volume 2, Basic Research, pp 86-115. New York: Springer-Verlag.

21. Fraenkel, J and Wallen, N (1993). How to Design and Evaluate Research in Education (Second edition) McGraw-Hill Inc.: New York.

22. Gerber, G, Boulton-Lewis, G and Bruce, C (1995). Children's understanding of graphic representation of quantitative data. *Learning and Instruction,* 5; pp 77-100.

23. Ghebru, S (2000). An analysis of communicational strategies of the Grade Nine Eritrean chemistry textbook. Unpublished MEd Dissertation, University of the Western Cape.

24. Glasgow, J (1988). Science Teacher Education Materials Development Project: Methodology. In Glasgow, J (Ed.) Resources for Science Educators. Kingston Jamaica: United Co-operative Printers.

25. Gobert, J and Clement, J (1999). Effects of student-generated diagrams versus student-generated summaries on conceptual understanding of causal and dynamic knowledge in plate tectonics. *Journal of Research in Science Teaching,* 36 (1): pp 39-53.

University of Cape Town

26. Goldsmith, E (1984). Research into Illustration: an Approach and an Review. Cambridge: Cambridge University Press.

27. Hortin, J.A (1994), Theoretical Foundations of Visual Learning. In Moore, D and Dwyer, F (Eds.) Visual Literacy: A Spectrum of Visual Learning, pp 5-30. New Jersey: Educational Technology Publications.

28. Holliday, W (1990). Textbook illustrations- fact or filler? *The Science Teacher,* 57 (9): pp 27-29.

29. Kearsey, J and Turner, S (1999). How useful are figures in school biology textbooks? *Journal of Biological Education,* 33 (2): pp 87-94.

30. Keeves, J.P (Eds) (1988). Educational Research, Methodology and Measurement: An International Handbook. Pergamon Press: Australia.

31. King, W (1990). Integrated science in the Caribbean. *New Trends in Integrated Science Teaching,* (VI): pp 147-157.

32. Kirby, J (1993). Collaborative and competitive effects of verbal and spatial processes. *Learning and Instruction,* 3: pp 201-214.

33. Kress, G and van Leeuwen, T (1996). The Grammar of Visual Design. New York: Rocetledge.

34. Langhan, D.P (1993). The textbook as a source of difficulty in teaching and learning. HSRC Report Ed- 21/ 93.

35. Leonard, W and Penick, J (1993). What's important in selecting a biology textbook? *The American Biology Teacher,* 55: pp 14-19.

University of Cape Town

36. Levin, J, Anglin, G and Carney, R (1987). On Empirically Validating Functions of Pictures in Prose, In Willows, D and Houghton, A (Eds.) The Psychology of Illustration: Volume 1. Basic Research, pp 51-77. New York: Springer Verlag.

37. Levie, W (1987). Research on Pictures: A Guide to the Literature. In Willows, D and Houghton, M (Eds.) The Psychology of Illustration. Volume 1. Basic Research, pp 1-50. New York: Springer-Verlag.

38. Lowe, R (1993). Constructing a mental representation from an abstract technical diagram. *Learning and Instruction,* 3: pp 157-179.

39. Lowe, R (1993). Successful Instructional Diagrams. London: Kogan Page Ltd.

40. Mayer, R and Anderson, R (1992). The instructive animation: helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology,* 84 (4): pp 444-452.

41. Mayer, R, Bove, W, Bryman, A, Mars, R and Tapangco, C (1996). When less is more: meaningful learning from visual and verbal summaries of science textbook lessons, *Journal of educational Psychology,* 88 (1): pp 64-73.

42. Mayer, R (1993). Comprehension of graphics in texts: an overview. *Learning and Instruction,* 3: pp 239-245.

43. Mayer, R and Gallini, J (1990). When is an illustration worth ten thousand words? *Journal of Educational Psychology,* 82 (4): pp 715-726.

44. Mayer, R and Moreno, R (1998). A split attention effect in multimedia learning: evidence for dual processing systems in working memory. *Journal of Educational Psychology,* 90 (2): pp 312-320.

University of Cape Town

45. Mayer, R (1989). Systematic thinking fostered by illustrations in scientific text. *Journal of Educational Psychology*, 81 (2): pp 240-246.

46. McMillan, J and Schumacher, S (1993). Research in Education (Third Edition). Harper Collins College Publishers: New York.

47. Miller, H and Burton, K (1994). Images and Imagery Theory. In Moore, D.M and Dwyer, F.M (Eds.) Visual Literacy: A Spectrum of Visual Learning, pp 65-84. New Jersey: Educational Technological Publications.

48. Moore, D.M and Dwyer, F.M (Eds.) (1994). Visual Literacy: A Spectrum of Visual Learning. New Jersey: Educational Technological Publications.

49. Opie, F, Enderstein, G and Amosun, O (1999). New Nation Science Grade 7. Hodder and Stoughton: Johannesburg.

50. O'Hare, D and Cook, D (1983). Children's sensitivity to different modes of colour use in art. *British Journal of Educational Psychology*, 53: pp 267-277.

51. Peeck, J (1993). Increasing picture effects in learning from illustrated text. *Learning and Instruction*, 3: pp 227-238.

52. Peeck, J (1987). The role of illustrations in processing and remembering text. In Willows, D and Houghton, M (Eds.) The Psychology of Illustration: Volume 1. Basic Research, pp 115-147. New York: Springer-Verlag.

53. Plass, J, Leutner, D, Chun, D and Mayer, R (1998). Supporting visual and verbal learning processes in a second-language multimedia-learning environment. *Journal of Educational Psychology*, 96 (1): pp 25-36.

54. Ramsey, I (1989). An investigation of children's verbal responses to selected art styles. *Journal of Educational Research*, 83 (1): pp 46-51.

University of Cape Town

55. Reid, D (1984). The picture superiority effect and biological education. *Journal of Biological Education*, 18 (1): pp 29-36.

56. Reid, D (1990 a). The role of pictures in learning biology: part 1, perception and observation. *Journal of Biological Education*, 24 (3): pp 161-172.

57. Reid, D (1990 b). The role of pictures in learning biology: part 2, picture-text processing. *Journal of Biological Education*, 24 (4): pp 251-258.

58. Reid, D and Beveridge, M (1986). Effects of text illustration on childrens' learning of a school science topic. *British Journal of Educational Psychology*, 56 (3): pp 294-303.

59. Reid, D and Beveridge, M (1990). Reading illustrated science texts: a micro-computer based investigation of children's strategies. *British Journal of Educational Psychology*, 60 (1): pp 76-87.

60. Reid, D, Briggs, N, and Beveridge, D (1983). The effects of picture upon the readability of a school science topic. *British Journal of Educational Psychology*, 53: pp 327-335.

61. Reid, D and Beveridge, M and Wakefield, P (1986). The effect of ability, colour and art form on children's perception of biological pictures. *British Journal of Educational Psychology*, 6: pp 9-18.

62. Reid, D and Wicks, S (1988). Young children's perception of colour on a school microcomputer. *Programmed Learning and Educational Technology*, 25: pp 348-353.

University of Cape Town

63. Rowe, M. B.(Ed) (1990). What Research Says to the Science Teacher. The Process of Knowing. National Science Teacher Association.

64. Russell-Gebbett (1984). Pupils' perceptions of three-dimensional studies in biology lessons. *Journal of Biological Education,* 18 (3): pp 220-225.

65. Sanders, M (1995). The nature and remediation of spatial problems associated with interpreting diagrams of biological sections. Unpublished PhD thesis, University of Cape Town.

66. Schnotz, W (1993). Introduction. *Learning and Instruction,* 3: pp 151-155.

67. Schnotz, W, Pickard, M and Hron, A (1993). How do successful and unsuccessful learners use text and graphics? *Learning and Instruction,* 3: pp 181-199.

68. Seels, B (1994). Visual Literacy: The Definition Problem. In Moore, D and Dwyer, F (Eds.) (1994). Visual Literacy: A Spectrum of Visual Learning, pp 97-112. Educational technological Publications: New York.

69. Soyibo, K (1994). Misleading labellings in biology textbook drawings. *Australian Science Teachers Journal,* 40 (2): pp 10-14.

70. Soyibo, K (1999). Gender differences in Caribbean students' performances on a test of errors in biological labelling, *Research in Science and Technological Education,* 17 (1): pp 75-82.

71. Soyibo, K (1995). Using concept maps to analyse textbook representations of respiration. *The American Biology Teacher,* 57 (6): pp 344-351.

72. Soyibo, K (1996). A comparison of communication strategies among three Caribbean high school biology textbooks. *Journal of Biological Education,* 30 (3): pp 190-194.

University of Cape Town

73. Stern, R and Robinson, R (1994). Perception and its Role in Communication and Learning. In Moore, D.M. and Dwyer, F.M. (Eds.) Visual Literacy: A Spectrum of Visual Learning. New Jersey: Educational Technology Publications.

74. Turbayne, C. M. (1970). The Myth of the Metaphor. New Haven: Yale University Press.

75. Van Dalen, D (1966). Understanding Educational Research. McGraw-Hill: New York.

76. Wu, H-M and Salmon, R (1993). Effective use of pictures as extra stimulus prompts. *British Journal of Educational Psychology*, 63 (1): pp 144-160.

77. Young, D and Fraser, B (1994). Gender differences in science achievement: do schools make a difference? *Journal of Research in Science Teaching*, 31 (8): pp 857-871.

University of Cape Town

Bibliography

1. Abimola, I and Baba, S (1996). Misconceptions and alternative concepts in science textbooks: the role of the teachers as filters. *The American Biology Teacher,* 58 (1): pp 14-19.

2. Barass, R (1984). Some misconceptions and understandings perpetuated by teachers and textbooks of biology. *Journal of Biological Education,* 18 (3), pp 201-205.

3. Bottril, J and Lock, R (1993). Do students learn more from pictures or from text? - a pilot study. *School Science Review,* 74 (269): pp 109-112.

4. Brooks, M, Glenn, S and Crozier, W (1988). Pre-school children's preferences for drawings of a similar complexity to their own. *British Journal of Educational Psychology,* 58 (2): pp 165-171.

5. Cheng, P (1999). Interactive law encoding diagrams for learning and instruction. *Learning and Instruction,* 9: pp 309-325.

6. Cox, R (1999). Representation construction, externalised cognition and individual differences. *Learning and Instruction,* 9: pp 343-363.

7. Messaris, P (1994). Visual Literacy- Image, Mind, Reality. Westview Press, Incorporate: Oxford.

8. Pillay, P (1998). Cognitive processes and strategies employed by children to learn spatial representations. *Learning and Instruction,* 8 (1): pp 1-18.

9. Reiman, P (1999). The role of external representations in distributed problem solving. *Learning and Instruction,* 9: pp 411-418.

University of Cape Town

10. Rogers. Y (1999). What is different about interactive graphical representation? *Learning and Instruction*, 9: pp 419-425.

University of Cape Town

APPENDIX 1a

LETTER OF DONATION

FOR TEXTBOOKS

University of Cape Town

3 Jangada Street
Sun Valley
FISH HOEK
12 January, 2000

FOR ATTENTION : Ms GREG MCCTCHEON

Hodder & Stoughton Educational
Southern Africa
P.O. Box 3948
RANDBURG

REQUEST FOR THE TEMPORARY LOAN OR DONATION OF TEXTBOOKS

Our telephonic conversation of 12 January 2000 refers.

This year I have applied to study for a Masters Degree in Science Education at the University of Cape Town, as a sequel to my B.Sc (Hons) Degree and HDE, and I am writing this letter with the approval of my potential future research supervisor,Prof K Rochford.

Many Science teachers rely heavily on their textbooks and the introduction of new textbooks can be very costly.

Your NEW NATION SCIENCE GRADE 7 will be implemented in schools as of this year.I propose to carry out a research study on the perceptions and interpretations and understanding by science students on the drawings in this particular book.

I have approached lecturers at Michealis School of Fine Art at UCT as well as the Medical Graphics Department at Groote Schuur Hospital and have gained enthusiastic input and support as co- participants in the proposed investigation.

For the next part of the research, I will be presenting copies of the book to students as well as teachers to find out their perceptions of the drawings. I intend to approach about 900 students in this research,in both advantaged and disadvantaged schools to which I have assured access.

University of Cape Town

I therefore request about 100 copies of the book on loan for a month or two. If this number is excessive, I would appreciate any amount which will enable me to complete the next stage of my research.

I wish to ensure you that any findings of the research will be sent to you firstly so that any recommendations can be implemented in the next publication of this book.I would anticipate that my preliminary findings would be available by April 30th.

If my request is approved, the books can be forwarded, on loan , to :

Prof K Rochford
UCT
School of Education
Middle Campus
Rondebosch
7700

To show you the seriousness of our research, I included a few pages to show the publications of students in the Education Department.

Thanking you.

Yours faithfully

K.R.Jacobs

University of Cape Town

3 Jangada Street
Sun Valley
FISH HOEK
29 February, 2000

FOR ATTENTION : Ms GREG MCCTCHEON

Hodder & Stoughton Educational
Southern Africa
P.O. Box 3948
RANDBURG

DONATION OF NEW NATION SCIENCE GRADE 7 TEXTBOOK

I hereby wish to thank you for the donation of the above- mentioned textbook.

The textbooks have finally arrived after so much phoning around with regard to their arrival. I also wish to extend my gratitude for the effort you did put in to trace the textbooks after hearing that they did not arrive.

I wish to ensure you that my preliminary findings of the research will be send to you firstly, so that any recommendations may be implemented in the next publication of the textbook.

After gathering the data , the textbooks will be donated to teachers of disadvantaged schools, who will also participate in this research.

If you wish to find out anything with regard to my research, I can be contacted at tel :

(021) 3613351 (W)

(021) 7853865 (H)

cell : 0839533303

E- mail: JCBKEI002@MAIL.UCT.AC.ZA

Thanking you.

Yours faithfully

K.R.Jacobs

University of Cape Town

APPENDIX I b

LETTER OF PERMISSION TO DO RESEARCH AT A SCHOOL

University of Cape Town

UNIVERSITY OF CAPE TOWN

School of Education

Room 4.05
New Education Building
University of Cape Town
Private Bag
Rondebosch 7701

Ph: +27(0)21 650 2769
Fax: +27(0)21 650 3489

To Whom It May Concern: Students' evaluation of science textbook diagrams

This year I have applied to study for a Masters Degree in Science Education at the University of Cape Town.

Many science teachers rely heavily on their textbooks and the introduction of new textbooks can be costly.

The New Nation Science Grade 7 textbook will be utilised in schools this year. I propose to carry out a research study on the perceptions and understanding by science students of the drawings in this particular book.

I have approached lecturers at Michealis School of Fine Art at UCT as well as the Medical Graphics Department at Groote Schuur Hospital and have gained their enthusiastic input and support as co- participants in the proposed investigation.

For the next part of the research, I will be presenting copies of the book to learners as well as educators, to record their perceptions of the quality and relevance of the drawings. I intend to approach about 1000 learners in both advantaged and disadvantaged schools.

I therefore request your permission to hand out 30 copies of the textbook, as well as the evaluation worksheet, to the Grade 8 learners as well as their educators.The evaluation worksheet may be completed at home and returned the following day, together with the 30 textbooks. In this manner no teaching time will be lost.

I wish to ensure confidentiality in that no learners' name or schools' name will be asked.

Thanking you for your participation

Yours faithfully

Keith Jacobs

University of Cape Town

APPENDIX 2 a

THE TEXTBOOK QUESTIONNAIRE

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
97	Gull in flight							
98	Penguin							
99	Sunbird							
100	Chicken							
103	Flight into danger							
107	Owl							
109	Flying fishermen							
116	Ostrich							
117	Inside an egg							
118	Development of chick							

2. **Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.**

I rate the drawing on page ..... highly because

(i) .....

.....

I rate the drawing on page ..... highly because

(ii) .....

.....

3. **Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.**

I rate the drawing on page ..... lowly because

(i) .....

.....

I rate the drawing on page ..... lowest because

(ii .....

.....

4. **Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.**

Page	Drawing	Yes or No	Reason
97	Gull in flight		
98	Penguin		
117	Inside an egg		
118	Development of chick		

Indicate the correct response with a cross (x)

GENDER

Male	
Female	

AGE

12- 13 years	
14- 15 years	
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain							
146	Water cycle							
151	Penguins in peril							
152	Penguins							
153	Jackass penguins							
154	Kelp gulls							
155	Kelp gull feeding							
157	Hippos							
164	Mussels							
166	Platannas							

2. **Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.**

I rate the drawing on page ..... highly because

(i) .....

.....

I rate the drawing on page ..... highly because

(ii) .....

.....

3. **Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.**

I rate the drawing on page ..... lowly because

(i) .....

.....

I rate the drawing on page ..... lowest because

(ii .....

.....

4. **Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.**

Page	Drawing	Yes or No	Reason
152	Penguins		
153	Jackass Penguins		
157	Hippos		
164	Mussels		
166	Platannas		

Indicate the correct response with a cross (x)

GENDER

Male	
Female	

AGE

12- 13 years	
14- 15 years	
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
1	Flea							
2	Flea sucking							
3	Lamp							
5	Fly							
7	Swarming Locust							
10	Bees at work							
13	Perlemoen							
14	Perlemoen							
20	Spiders Web							
23	Poisonous Spiders							

2. **Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.**

I rate the drawing on page ..... highly because

(i) .....

.....

I rate the drawing on page ..... highly because

(ii) .....

.....

3. **Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.**

I rate the drawing on page ..... lowly because

(i) .....

.....

I rate the drawing on page ..... lowest because

(ii .....

.....

4. **Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.**

Page	Drawing	Yes or No	Reason
3	Lamp		
7	Swarming Locust		
13	Perlemoen		

Indicate the correct response with a cross (x)

GENDER

Male	
Female	

AGE

12- 13 years	
14- 15 years	
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
25	Asteroid							
26	Dinosaurs							
27	Properties of Water							
29	Lake							
34	Greenhouse Effect							
37	Squid hunting							
38	Water							
40	Warming up water							
44	Foundation of earth							
47	Shape of things							

2. **Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.**

I rate the drawing on page ..... highly because

(i) .....

.....

I rate the drawing on page ..... highly because

(ii) .....

.....

3. **Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.**

I rate the drawing on page ..... lowly because

(i) .....

.....

I rate the drawing on page ..... lowest because

(ii .....

.....

4. **Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.**

Page	Drawing	Yes or No	Reason
26	Dinosaurs		
29	Lake		
37	Squid hunting		
38	Water		
47	Shape of things		

Indicate the correct response with a cross (x)

GENDER

Male	
Female	

AGE

12- 13 years	
14- 15 years	
16- 17 years	

University of Cape Town

APPENDIX 2 b

THE ENGLISH VERSION

OF THE

PICTORIAL QUESTIONNAIRE

University of Cape Town

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Look at drawings 1, 2 and 3. Which of these pictures have you already learnt about in class? Tick the appropriate boxes.

	YES	NO
Drawing 1	☐	☐
Drawing 2	☐	☐
Drawing 3	☐	☐

Question 1

Study the following drawings (numbers 1 and 2) and answer the following questions.

I think that drawing 1 represents ..... and I think

that drawing 2 represents .....

Question 2a

Study the drawing of the inside of the egg of a chick(number 3).
Does it look like an egg?

Why? .....

Why not? .....

Question 2b

If you were given an instruction to improve the drawing, what changes, if any, would you suggest with regard to:

a) The colour of each part:.....

b) The positions of certain parts in the drawing: .....

.....

c) The accuracy of the labels: .....

d) The size of the "embryo" in the picture: .....

e) The shape of the drawing: .....

University of Cape Town

Question 2c

In your opinion, circle the appropriate answers below and give reasons.

Drawing 1 is a well drawn / poorly drawn diagram.

Reason : .....

Drawing 2 is a well drawn / poorly drawn diagram.

Reason: .....

Question 3

The sequences of drawings (numbered 1 to 5) represents the development of a chick in a fertilised egg. The labels (numbered a to e) are supplied. Write down the correct numbers of the labels, in the spaces provided below, next to the labels of the drawings.

Drawing number	Label
1	
2	
3	
4	
5	

Indicate your age with a cross (x)

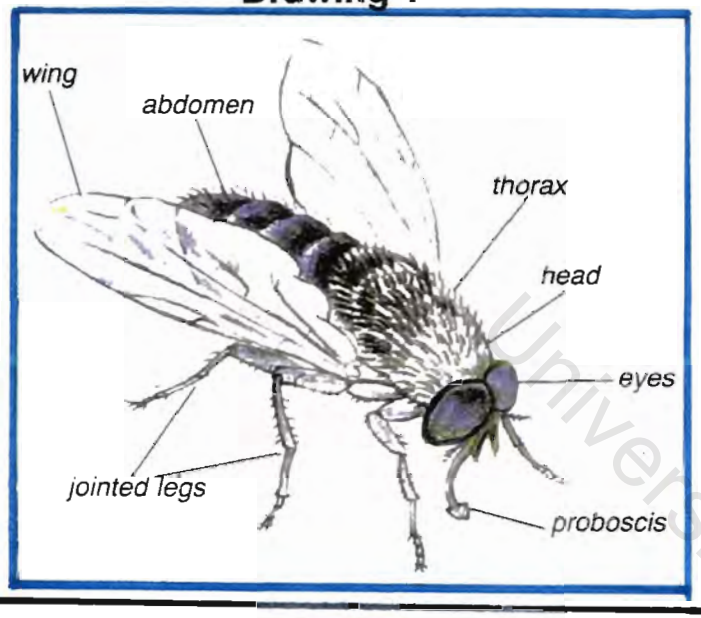
	My Age
12-13 years	
14-15 years	
16-17 years	

Be assured that all your answers are not for marks and will remain totally confidential.

Thank you for your participation.

University of Cape Town

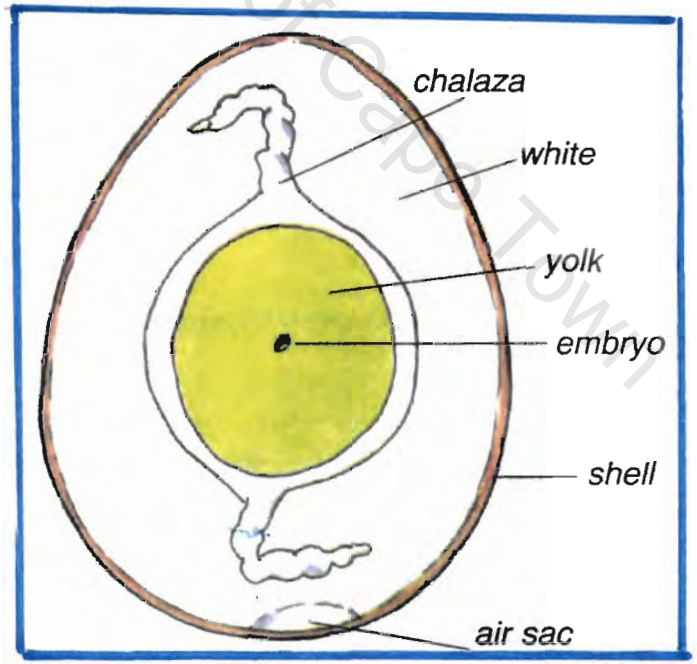
Drawing 1



Drawing 2



Drawing 3



University of Cape Town

Drawing 1



Drawing 2



Drawing 3



Drawing 4



Drawing 5



Label a : The newly laid fertilised egg

Label b : The growing embryo in the egg

Label c : The newly formed chick in the egg

Label d : The chick breaks the shell

Label e : The chicken has just hatched

University of Cape

APPENDIX 2 c

THE XHOSA VERSION

OF THE

PICTORIAL QUESTIONNAIRE

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Jonga kulemifanekiso 1, 2 ,3. Yeyiphi osuwufunde ngayo krwela kwezo zizizo.

	EWE	HAYI
Mfanekiso 1		
Mfanekiso 2		
Mfanekiso 3		

Umbuzo 1

Jonga kulemifanekiso 1,2, uphendule

Ndicinga ukuba umfanekiso 1 u .....

ndicinga ukuba umfanekiso 2 u .....

Umbuzo 2a

Funda umfanekiso 3 (umphakathi weqanda).
Ujongeka njengeqanda?

Ukuba kunjalo, ngoba?.....

Ukuba akunjalongo ngoba?.....

Umbuzo 2b

Ukuba ngaba ubunikwe umyalelo wokuphucula umzobo, zeziphi izinto obunokuzitshintsha/ cebisa malunga

a) Umbala wento nganye:.....

b) indawo yamalungu athile kumzolo .....

.....

c) beka umbhalo(labels) endaweni ezifanelekileyo.....

.....

d) Ubungakanani be-embriyo .....

e) Ukumila komzobo: .....

University of Cape Town

Umbuzo 2c

Ngokucinga kwakho kwrela eyona iyiyo impendulo, unike isizathu.

Mfanekiso 1 : uzotywe kakuhle / kakubi

Isizatho : .....

Mfanekiso 2 : uzotywe kakuhle / kakubi

Isizatho: .....

Umbuzo 3

Ngokulandelelana kwemifanekiso (1-5), kuboniswa ukukhula kwentshontsho eqandeni.

Imibalo (labels a-e) inikiwe. Bhalo eyona elungileyo kusikhewu ecaleni komzobo.

Umzobo	Umbalo (Label)
1	
2	
3	
4	
5	

Krwela kwiminyaka efanelekileyo ngalo mzobo x

AGE	
12-13 years	
14-15 years	
16-17 years	

Qaphela ukuba impendulo zakho awuzukufumana manqaku ngazo yaye ziyakuhlala zifihliwe aziyi kuboniswa nabani.

Enkosi ngentsebenziswano

University of Cape Town

APPENDIX 3

TABLES 4.10 – 4.33

THE RESPONDENTS' RATINGS

TO THE ILLUSTRATIONS'

SPECIFIED CRITERIA

University of Cape Town

Table 4.10 (a) Summary of the results of the 190 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Na = 190) Disadvantaged*	*Mean Group 2 (Ne = 172) Advantaged*	*SD (a)*	*SD (e)*	*t-value*	*p-value*
Asteroid	25	2.90	2.57	0.99	1.10	3.00	0.0029 **
Dinosaurs	26	3.07	2.73	1.09	1.11	2.73	0.004 **
Properties of water	27	3.17	2.70	1.20	1.08	3.92	0.0001 **
Lake	29	3.37	2.97	1.17	1.10	3.38	0.0008 **
Greenhouse effect	34	2.94	2.79	1.21	1.19	1.25	0.2127
Squid hunting	37	3.27	3.51	1.07	1.03	- 1.94	0.0531
Water	38	3.26	2.84	1.20	1.10	3.48	0.0006 **
Warming up water	40	3.07	2.88	1.15	1.02	1.66	0.0982
Foundation of earth	44	3.56	3.77	1.22	1.19	- 1.70	0.0904
Shape of things	47	3.08	2.94	1.18	1.15	1.12	0.2646

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing less satisfaction with the size of the illustrations than sample (a) of the disadvantaged learners.

University of Cape Town

Table 4.10 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to the perception of the **size** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nb = 178 Disadvantaged***	***Mean Group 2 (Nf = 237) Advantaged***	***SD (b)***	***SD (f)***	***t-value***	***p-value***
Flea	1	2.55	3.17	1.06	1.07	- 5.91	0.0000 **
Flea sucking	2	3.26	3.68	1.20	1.11	- 3.68	0.0003 **
Lamp	3	3.03	3.20	1.22	1.11	- 1.48	0.1386
Fly	5	3.62	4.26	3.31	0.99	- 5.67	0.0000 **
Swarming locust	7	3.35	4.10	1.19	0.96	- 7.16	0.0000 **
Bees at work	10	2.97	3.95	1.20	0.88	- 9.59	0.0000 **
Perlemoen (1)	13	2.95	3.94	1.15	0.95	- 9.75	0.0000 **
Perlemoen (2)	14	2.52	2.69	1.14	1.01	- 1.66	0.0983
Spider's web	20	3.40	4.42	1.30	0.89	- 9.54	0.0000 **
Poisonous spiders	23	3.07	3.66	1.27	0.97	- 5.36	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (f) of advantaged learners expressing more satisfaction with the size of the illustrations than sample (b) of the disadvantaged learners.

University of Cape Town

Table 4.10 (c) Summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nc = 237 Disadvtaged*	*Mean Group 2 (Ng = 166) Advantaged*	*SD (c)*	*SD (g)*	*t-value*	*p-value*
Gull in flight	97	2.95	2.65	0.94	0.93	3.20	0.002 **
Penguin	98	2.97	2.45	1.06	0.86	5.21	0.0000 **
Sunbird	99	3.37	3.43	1.06	0.96	0.60	0.5461
Chicken	100	2.65	2.14	1.08	0.87	5.07	0.0000 **
Flight into danger	103	3.19	3.30	1.10	1.01	-0.99	0.3216
Owl	107	3.65	3.84	1.04	0.89	1.91	0.0571
Flying fishermen	109	3.05	3.07	1.08	0.92	-0.21	0.8338
Ostrich	116	3.61	3.71	1.15	0.97	-0.94	0.3459
Inside an egg	117	3.40	3.54	1.13	0.91	-1.34	0.1814
Development of chick	118	2.99	3.65	1.16	0.99	-5.99	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (g) of advantaged learners expressing more satisfaction with the size of the illustrations than sample (c) of the disadvantaged learners.

University of Cape Town

Table 4.10 (d) Summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nd = 252 Disadvantaged***	***Mean Group 2 (Nh = 200) Advantaged***	***SD (d)***	***SD (h)***	***t-value***	***p-value***
Days of big Rain	145	2.46	2.31	0.97	0.98	1.59	0.1135
Water cycle	146	3.66	3.78	1.04	1.07	- 1.13	0.2599
Penguins in peril	151	2.73	2.77	1.02	1.07	- 0.44	0.6576
Penguins	152	3.42	3.44	1.09	1.03	- 0.14	0.8862
Jackass penguins	153	3.19	3.48	0.98	0.98	- 3.16	0.002 **
Kelp gulls	154	3.10	3.22	1.07	1.05	- 1.20	0.0310 *
Kelp gull feeding	155	2.75	3.02	1.17	1.22	- 2.43	0.015 *
Hippos	157	2 26	2.46	1.07	1.04	- 1.98	0.048 *
Mussels	164	2 70	3.10	1.20	1.20	- 3.46	0.0006 **
Platannas	166	2.83	3.13	1.19	1.19	- 2.62	0.009 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (e) of advantaged learners expressing more satisfaction with the size of the illustrations than sample (a) of the disadvantaged learners.

University of Cape Town

Table 4.11 (a) Summary of the results of the 190 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the satisfaction of the **clearness** illustrations.

Drawing	*Page*	***Mean Group 1 (Na = 190) Disadvantaged***	***Mean Group 2 (Ne = 172) Advantaged***	***SD (a)***	***SD (e)***	***t-value***	***p-value***
Asteroid	25	3.20	2.82	1.07	1.04	3.45	0.0006 **
Dinosaurs	26	3.57	3.63	1.28	1.28	- 0.45	0.65
Properties of water	27	3.66	3.65	1.36	1.16	0.07	0.94
Lake	29	3.78	3.65	1.31	1.14	0.98	0.3295
Greenhouse effect	34	3.45	3.36	1.38	1.24	0.61	0.5395
Squid hunting	37	3.16	3.50	1.35	1.15	- 2.63	0.009 **
Water	38	3.66	3.15	1.37	1.19	3.83	0.00012 **
Warming up water	40	3.61	3.34	1.34	1.10	2.05	0.041 *
Foundation of earth	44	3.90	3.81	1.25	1.19	0.68	0.5003
Shape of things	47	3.62	3.23	1.25	1.23	3.02	0.003 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (e) of advantaged learners expressing less satisfaction with the clearness of the illustrations than sample (a) of the disadvantaged learners.

University of Cape Town

Table 4.11 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **clearness** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nb = 178) Disadvantaged*	*Mean Group 2 (Nf = 237) Advantaged*	*SD (b)*	*SD (f)*	*t-value*	*p-value*
Flea	1	2.92	3.50	1.10	1.17	- 5.12	0.00000 **
Flea sucking	2	2.97	3.91	1.41	1.18	- 7.31	0.0000 * *
Lamp	3	3.19	4.04	139	3.77	- 2.85	0.005 **
Fly	5	3.91	4.51	1.39	0.89	- 5.34	0.0000 **
Swarming Locust	7	3.75	4.49	1.33	0.85	- 6.80	0.0000 **
Bees at work	10	3.36	4.29	1.31	0.93	- 8.31	0.0000 **
Perlemoen (1)	13	2.79	3.09	1.34	1.14	- 2.45	0.015 *
Perlemoen (2)	14	3.10	4.18	1.29	0.94	- 9.86	0.0000 **
Spider's web	20	3.82	4.70	1.39	0.75	- 8.17	0.0000 **
Poisonous Spiders	23	3.49	4.32	0.98	1.38	- 7.07	0.0000 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (g) of advantaged learners expressing less satisfaction with the clearness of the illustrations than sample (c) of the disadvantaged learners.

University of Cape Town

Table 4.11 (c) Summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **clearness** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nc = 237) Disadvantaged*	*Mean Group 2 (Ng = 166) Advantaged*	*SD (c)*	*SD (g)*	*t-value*	*p-value*
Gull in flight	97	3.55	3.01	1.10	0.84	5.32	0.0000 **
Penguin	98	3.51	2.99	1.13	1.00	4.73	0.0000 **
Sunbird	99	3.93	4.29	1.25	0.92	- 3.06	0.002 **
Chicken	100	2.75	1.73	2.32	1.12	5.23	0.0000 **
Flight into Danger	103	3.51	3.52	1.24	0.87	- 0.01	0.9916
Owl	107	3.92	4.17	1.24	0.87	- 2.29	0.023 *
Flying Fishermen	109	2.97	3.04	1.17	1.06	- 0.60	0.546
Ostrich	116	3.88	3.95	1.19	0.88	- 0.66	0.5099
Inside an Egg	117	3.77	3.42	1.24	1.02	3.05	0.0024 **
Development of chick	118	3.47	3.63	1.27	1.14	- 1.29	0.1974

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the sample (g) of advantaged learners expressing more satisfaction with the clearness of the illustrations than sample (c) of the disadvantaged learners.

Table 4.11 (d) Summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **clearness** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nd = 252) Disadvantaged***	***Mean Group 2 (Nh = 200) Advantaged***	***SD (d)***	***SD (h)***	***t-value***	***p-value***
Days of big Rain	145	3.07	2.83	1.12	1.03	2.33	0.027 *
Water cycle	146	4.12	3.97	1.13	1.21	1.40	0.1631
Penguins in peril	151	2.51	2.42	1.20	1.26	0.78	0.4351
Penguins	152	3.98	4.06	1.12	1.00	- 0.78	0.4351
Jackass penguins	153	3.80	4.03	1.05	1.10	- 2.23	0.027 *
Kelp gulls	154	3.66	3.71	1.11	1.23	- 0.40	0.6866
Kelp gull Feeding	155	3.30	3.72	1.30	1.18	- 3.53	0.0005 **
Hippos	157	2.35	2.44	1.25	1.25	- 0.76	0.4458
Mussels	164	2.73	3.03	1.28	1.27	- 2.46	0.0142 *
Platannas	166	3.02	3.01	1.30	1.21	0.05	0.9603

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (h) of advantaged learners expressing more satisfaction with the clearness of the illustrations than sample (d) of the disadvantaged learners.

University of Cape Town

Table 4.12 (a) Summary of the results of the 189 disadvantaged (Na) vs. 172 advantaged learners (Ne) with regard to the satisfaction of the **colour** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Na = 189) Disadvantaged***	***Mean Group 2 (Ne = 172) Advantaged***	***SD (a)***	***SD (e)***	***t-value***	***p-value***
Asteroid	25	2.92	2.58	1.12	1.15	2.88	0.004 **
Dinosaurs	26	3.78	3.88	1.23	1.15	- 0.81	0.4160
Properties of water	27	3.27	3.38	1.36	1.22	- 0.79	0.4326
Lake	29	3.75	3.44	1.30	1.25	2.33	0.021 *
Greenhouse effect	34	3.36	3.27	1.28	1.17	0.78	0.4339
Squid hunting	37	3.01	3.28	1.32	1.15	-2.10	0.0363 *
Water	38	3.11	2.80	1.44	1.19	2.25	0.025 *
Warming up water	40	3.39	3.08	1.23	1.18	2.47	0.014 *
Foundation of earth	44	3.46	3.57	1.27	1.21	- 0.84	0.400
Shape of things	47	2.86	2.73	1.23	1.27	0.94	0.3471

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing less satisfaction with the colour of the illustrations than sample (a) of the disadvantaged learners.

Table 4.12 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **colour** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nb = 178) Disadvantaged*	*Mean Group 2 (Nf = 237) Advantaged*	*SD (b)*	*SD (f)*	*t-value*	*p-value*
Flea	1	3.12	3.39	1.25	1.16	- 2.33	0.020
Flea sucking	2	3.32	3.54	1.30	1.18	- 1.87	0.0628
Lamp	3	3.26	3.68	1.27	1.12	- 3.55	0.0004
Fly	5	3.28	3.39	1.34	1.14	- 0.94	0.3477
Swarming locust	7	3.53	4.27	1.29	0.93	6.93	0.00000
Bees at work	10	3.02	3.87	1.23	1.16	- 7.28	0.00000
Perlemoen (1)	13	2.93	3.45	1.30	1.03	- 4.66	0.000004
Perlemoen (2)	14	3.05	3.71	1.23	1.03	-6.08	0.000000
Spider's web	20	3.44	4.54	1.32	0.80	-10.73	0.00000
Poisonous spiders	23	3.28	4.31	1.29	0.93	-9.59	0.00000

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing more satisfaction with the colour of the illustrations than sample (b) of the disadvantaged learners.

Table 4.12 (c) Summary of the results of the 236 disadvantaged (Nc) vs. 164 advantaged learners (Ng) with regard to satisfaction with the **colour** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nc = 236) Disadvantaged***	***Mean Group 2 (Ng = 164) Advantaged***	***SD (c)***	***SD (g)***	***t-value***	***p-value***
Gull in flight	97	3.65	3.02	1.11	1.13	5.49	0.0000 **
Penguin	98	3.56	2.82	1.13	1.13	6.36	0.0000 **
Sunbird	99	3.86	4.33	1.13	0.87	-4.44	0.0000 **
Chicken	100	3.06	1.29	1.52	0.76	13.85	0.0000 **
Flight into danger	103	2.77	3.55	1.46	1.07	-5.86	0.0000 **
Owl	107	3.59	3.94	1.18	1.04	-3.02	0.0027 **
Flying fishermen	109	3.45	2.89	1.29	1.02	4.69	0.0000 **
Ostrich	116	3.34	3.56	1.19	1.09	-1.86	0.063
Inside an egg	117	3.48	2.93	1.14	1.09	4.80	0.0000 **
Development of chick	118	2.95	3.37	1.29	1.11	-3.37	0.0008 **

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (g) of advantaged learners expressing an even satisfaction with the colour of the illustrations than sample (c) of the disadvantaged learners.

Table 4.12 (d) Summary of the results of the 251 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **colour** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nd = 251) Disadvantaged*	*Mean Group 2 (Nh = 200) Advantaged*	*SD (d*	*SD (h)*	*t-value*	*p-value*
Days of big rain	145	3.58	3.50	1.15	1.14	0.75	0.4570
Water cycle	146	4.13	4.24	1.03	0.85	-1.20	0.2298
Penguins in peril	151	2.61	2.36	1.22	1.17	2.21	0.028 *
Penguins	152	3.72	3.81	1.10	1.12	-0.84	0.4037
Jackass penguins	153	3.68	3.81	1.10	1.05	-1.26	0.2085
Kelp gulls	154	3.58	3.00	1.13	1.23	5.27	0.0000 **
Kelp gull feeding	155	3.17	3.08	1.20	1.38	0.75	0.4535
Hippos	157	2.35	2.53	1.16	1.17	-1.66	0.0983
Mussels	164	2.51	2.65	1.23	1.30	-1.21	0.2282
Platannas	166	2.73	2.62	1.27	1.14	1.03	0.3057

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (h) of advantaged learners expressing even satisfaction with the colour of the illustrations than sample (d) of the disadvantaged learners.

University of Cape Town

Table 4.13 (a) Summary of the results of the 190 disadvantaged (Na) vs. 171 advantaged learners (Ne) with regard to the satisfaction of the **relevance to the text**

Drawing	***Page***	***Mean Group 1 (Na = 190) Disadvantaged***	***Mean Group 2 (Ne = 171) Advantaged***	***SD (a)***	***SD (e)***	***t-value***	***p-value***
Asteroid	25	2.77	2.86	1.21	1.17	-0.67	0.5036
Dinosaurs	26	2.75	2.78	1.14	1.24	-0.21	0.8312
Properties of water	27	3.11	3.05	1.24	1.19	0.44	0.6606
Lake	29	2.86	2.83	1.16	1.07	0.25	0.8018
Greenhouse effect	34	2.98	3.24	1.25	1.23	-2.05	0.0413 *
Squid hunting	37	2.77	3.03	1.18	1.09	-2.19	0.0291 *
Water	38	3.01	2.90	0.30	1.19	0.89	0.3719
Warming up water	40	2.97	2.89	1.18	1.13	0.66	0.5108
Foundation of earth	44	3.12	3.33	1.29	1.25	-1.56	0.1202
Shape of things	47	2.89	2.95	1.22	1.08	- 0.47	0.6424

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing more satisfaction with the relevance to the text than sample (a) of the disadvantaged learners.

Table 4.13 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **relevance to the text**.

Drawing	*Page*	***Mean Group 1 (Nb = 178) Disadvantaged***	***Mean Group 2 (Nf = 237) Advantaged***	***SD (b)***	***SD (f)***	***t-value***	***p-value***
Flea	1	2.76	3.13	1.30	1.18	-3.00	0.0029 **
Flea sucking	2	2.79	3.33	1.20	1.19	-4.62	0.0000 **
Lamp	3	2.78	3.28	1.21	1.04	-4.57	0.0000 **
Fly	5	2.91	3.41	1.34	0.99	-4.38	0.0000 **
Swarming Locust	7	2.75	3.47	1.10	1.08	-6.68	0.0000 **
Bees at work	10	2.83	3.58	1.23	1.10	-6.55	0.0000 **
Perlemoen (1)	13	2.65	3.49	1.21	1.07	-7.47	0.0000 **
Perlemoen (2)	14	2.78	3.39	1.28	1.01	-5.49	0.0000 **
Spider's web	20	2.92	3.59	1.29	1.12	-5.69	0.0000 **
Poisonous Spiders	23	2.74	3.52	1.35	1.08	-6.49	0.0000 **

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (f) of advantaged learners expressing more satisfaction with the relevance to the text than sample (b) of the disadvantaged learners.

University of Cape Town

Table 4.13 (c) Summary of the results of the 237 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **relevance to the text.**

Drawing	***Page***	***Mean Group 1 (Nc = 237) Disadvantaged***	***Mean Group 2 (Ng = 166) Advantaged***	***SD (c)***	***SD (g)***	***t--value***	***p***
Gull in flight	97	3.03	2.88	1.21	0.96	1.37	0.1704
Penguin	98	2.96	3.00	1.16	0.91	-0.35	0.7250
Sunbird	99	3.10	3.52	1.19	0.99	-3.69	0.00026 **
Chicken	100	2.73	2.56	1.08	1.19	1.49	0.1372
Flight into danger	103	3.01	3.23	1.09	1.00	-2.08	0.0378 *
Owl	107	3.09	3.39	1.19	1.06	-2.64	0.0086 **
Flying fishermen	109	2.68	2.97	1.13	0.93	-2.76	0.006 **
Ostrich	116	3.15	3.36	1.14	1.01	-1.96	0.0511
Inside an egg	117	2.98	3.27	1.20	1.09	-2.42	0.0162 *
Development of chick	118	2.86	3.52	1.25	1.12	-5.38	0.0000 **

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (g) of advantaged learners expressing more satisfaction with the relevance to the text than sample (c) of the disadvantaged learners.

Table 4.13 (d) Summary of the results of the 251 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **relevance to the text.**

Drawing	***Page***	***Mean Group 1 (Nd = 251) Disadvantaged***	***Mean Group 2 (Nh = 200) Advantaged***	***SD (d)***	***SD (h)***	***t-value***	***p-value***
Days of big rain	145	2.88	2.98	1.27	1.18	-0.85	0.3975
Water cycle	146	3.24	3.24	1.18	1.06	0.01	0.9928
Penguins in peril	151	2.67	2.90	1.19	1.06	-2.18	0.0296 *
Penguins	152	2.89	3.17	1.15	1.10	-2.62	0.009 **
Jackass penguins	153	2.92	3.18	1.25	1.08	-2.28	0.023 *
Kelp gulls	154	2.96	3.21	1.18	1.16	-2.17	0.030 *
Kelp gull feeding	155	2.57	2.88	1.18	1.17	-2.74	0.0064 **
Hippos	157	2.61	2.89	1.19	1.27	-2.45	0.0145 *
Mussels	164	2.56	2.70	1.15	1.10	-1.24	0.2145
Platannas	166	2.68	2.80	1.25	1.13	-1.00	0.3166

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (h) of advantaged learners expressing more satisfaction with the relevance to the text than sample (d) of the disadvantaged learners.

University of Cape Town

Table 4.14 (a) Summary of the results of the 190 disadvantaged (Na) vs. 180 advantaged learners (Ne) with regard to the satisfaction of the **suitability for Africa**

Drawing	*Page*	***Mean Group 1 (Na = 190) Disadvantaged***	***Mean Group 2 (Ne = 180) Advantaged***	***SD (a)***	***SD (e)***	***t-value***	***p-value***
Asteroid	25	3.13	2.60	1.39	1.38	3.69	0.00026 **
Dinosaurs	26	2.71	2.33	1.34	1.31	2.70	0.007 **
Properties of water	27	3.60	3.72	1.37	1.36	-0.90	0.3685
Lake	29	3.46	3.63	1.32	1.21	-1.25	0.2111
Greenhouse Effect	34	2.98	3.14	1.31	1.30	-1.17	0.2413
Squid Hunting	37	2.70	2.89	1.37	1.27	-1.37	0.1706
Water	38	3.42	3.41	1.37	1.34	0.05	0.9569
Warming up water	40	3.19	3.16	1.35	1.23	0.20	0.8385
Foundation of earth	44	3.38	3.35	1.37	1.35	0.27	0.7896
Shape of Things	47	3.30	3.03	1.31	1.28	1.94	0.0535

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing less satisfaction with suitability for Africa than sample (a) of the disadvantaged learners.

Table 4.14 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 237 advantaged learners (Nf) with regard to satisfaction with the **suitability for Africa**.

Drawing	*Page*	*Mean Group 1 (Nb = 178) Disadvantaged*	*Mean Group 2 (Nf = 237) Advantaged*	*SD (b)*	*SD (f)*	*t-value*	*p-value*
Flea	1	3.14	3.39	1.44	1.49	-1.81	0.0718
Flea sucking	2	3.37	3.51	1.37	1.36	-1.15	0.2499
Lamp	3	3.52	3.72	1.32	1.25	-1.63	0.1049
Fly	5	3.65	3.84	1.30	1.23	-1.59	0.1127
Swarming Locust	7	3.57	3.82	1.33	1.29	-2.08	0.038 *
Bees at work	10	3.73	3.93	1.29	1.16	-1.68	0.0934
Perlemoen (1)	13	3.29	3.80	1.30	1.05	-4.40	0.00014 **
Perlemoen (2)	14	3.56	4.06	1.25	1.15	-4.54	0.00001 **
Spider's web	20	3.62	3.94	1.41	1.26	-2.57	0.011 *
Poisonous Spiders	23	3.44	3.78	1.37	1.28	-2.70	0.0071 **

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (f) of advantaged learners expressing more satisfaction with suitability for Africa than sample (b) of the disadvantaged learners.

Table 4.14 (c) Summary of the results of the 230 disadvantaged (Nc) vs. 166 advantaged learners (Ng) with regard to satisfaction with the **suitability for Africa.**

Drawing	*Page*	*Mean Group 1 (Nc = 237) Disadvantaged*	*Mean Group 2 (Ng = 166) Advantaged*	*SD (c)*	*SD (g)*	*t--value*	*p*
Gull in flight	97	3.73	3.82	1.18	1.36	-0.73	0.4686
Penguin	98	3.44	3.47	1.29	1.36	0.24	08100
Sunbird	99	3.52	3.96	1.18	1.04	-3.94	0.00001 **
Chicken	100	3.52	3.64	1.31	1.41	-0.89	0.3763
Flight into Danger	103	3.19	3.46	1.34	1.12	-2.11	0.0353 *
Owl	107	3.10	3.61	1.38	1.06	-4.00	0.00008 **
Flying fishermen	109	2.90	3.10	1.24	1.07	-1.68	0.0944
Ostrich	116	3.52	4.02	1.31	0.97	-4.21	0.00003 **
Inside an egg	117	3.26	3.77	1.31	1.16	-4.02	0.00007 **
Development of chick	118	3.18	3.98	1.35	0.90	-6.70	0.00000 **

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (g) of advantaged learners expressing more satisfaction with suitability for Africa than sample (c) of the disadvantaged learners.

Table 4.14 (d) Summary of the results of the 252 disadvantaged (Nd) vs. 200 advantaged learners (Nh) with regard to satisfaction with the **suitability for Africa.**

Drawing	*Page*	*Mean Group 1 (Nd = 251) Disadvantaged*	*Mean Group 2 (Nh = 200) Advantaged*	*SD (d)*	*SD (h)*	*t-value*	*p-value*
Days of big rain	145	3.43	3.22	1.35	1.48	1.58	0.1139
Water cycle	146	3.69	3.56	1.31	1.36	1.02	0.3073
Penguins in peril	151	2.82	2.97	1.34	1.34	-1.17	0.2437
Penguins	152	3.16	3.52	1.32	1.19	-2.98	0.0031 **
Jackass penguins	153	3.08	3.39	1.30	1.33	-2.46	0.014 *
Kelp gulls	154	3.15	3.33	1.38	1.22	-1.44	0.1503
Kelp gull feeding	155	2.84	3.04	1.29	1.27	-1.67	0.0950
Hippos	157	2.60	2.75	1.36	1.28	-1.12	0.2655
Mussels	164	3.69	3.19	1.28	1.40	3.95	0.00009 **
Platannas	166	2.67	2.89	1.32	1.33	-1.78	0.0753

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (h) of advantaged learners expressing more satisfaction with suitability for Africa than sample (d) of the disadvantaged learners.

Table 4.15 (a) Summary of the results of the 190 disadvantaged (Na) vs. 180 advantaged learners (Nd) with regard to the satisfaction of the **overall impression** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Na = 190) Disadvantaged***	***Mean Group 2 (Ne = 180) Advantaged***	***SD (a)***	***SD (e)***	***t-value***	***p-value***
Asteroid	25	2.98	2.89	1.26	1.04	0.75	0.4568
Dinosaurs	26	3.01	3.10	1.26	1.20	-0.70	0.4818
Properties of water	27	3.34	3.46	1.31	1.18	-0.87	0.3874
Lake	29	3.26	3.37	1.27	1.13	-0.81	0.4179
Greenhouse effect	34	2.95	3.22	1.40	1.18	-2.04	0.0423 *
Squid hunting	37	2.80	3.12	1.33	1.21	-2.44	0.0153 *
Water	38	3.02	3.07	1.27	1.28	-0.35	0.7290
Warming up water	40	3.00	2.84	1.29	1.17	1.22	0.0039 **
Foundation of earth	44	3.17	3.54	1.35	1.35	-2.66	0.0082 **
Shape of things	47	2.97	2.92	1.36	1.27	0.42	0.6759

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (e) of advantaged learners expressing more satisfaction with the overall impression of the illustration than sample (a) of the disadvantaged learners.

Table 4.15 (b) Summary of the results of the 178 disadvantaged (Nb) vs. 235 advantaged learners (Nf) with regard to satisfaction with the **overall impression** of the illustrations

Drawing	*Page*	***Mean Group 1 (Nb = 178) Disadvantaged***	***Mean Group 2 (Nf = 235) Advantaged***	***SD (b)***	***SD (f)***	***t-value***	***p-value***
Flea	1	2.83	3.43	1.18	1.15	-5.19	0.0000 **
Flea sucking	2	2.85	3.32	1.23	1.12	-4.07	0.0000 **
Lamp	3	3.10	3.76	1.26	1.03	-5.68	0.0000 **
Fly	5	3.13	4.02	1.43	1.09	-7.21	0.0000 **
Swarming locust	7	2.96	3.89	1.31	1.07	-7.90	0.0000 **
Bees at work	10	2.96	3.75	1.33	1.03	-6.51	0.0000 **
Perlemoen (1)	13	2.63	3.21	1.36	1.18	-4.66	0.0000 **
Perlemoen (2)	14	2.80	3.83	1.32	1.15	-8.39	0.0000 **
Spider's web	20	3.10	4.62	1.38	1.02	-11.26	0.0000 **
Poisonous spiders	23	2.68	3.96	1.35	1.24	-9.98	0.0000 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (f) of advantaged learners expressing more satisfaction with the overall impression of the illustration than sample (b) of the disadvantaged learners.

University of Cape Town

Table 4.15 (c) Summary of the results of the 237 disadvantaged (Nc) vs. 164 advantaged learners (Ng) with regard to satisfaction with the **overall impression** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nc = 237) Disdvantaged***	***Mean Group 2 (Ng = 164) Advantaged***	***SD (c)***	***SD (g)***	***t-value***	***p-value***
Gull in flight	97	3.47	3.13	1.15	0.96	3.06	0.0024 **
Penguin	98	3.40	3.23	1.04	094	1.69	0.0915
Sunbird	99	3.35	4.22	1.23	0.94	-7.55	0.0000 **
Chicken	100	2.87	1.99	1.21	1.16	7.21	0.0000 **
Flight into danger	103	3.17	3.42	1.25	1.15	-2.02	0.0443 *
Owl	107	3.29	3.84	1.27	1.01	-4.65	0.0000 **
Flying fishermen	109	3.18	2.74	1.32	1.04	3.52	0.00048 **
Ostrich	116	3.25	3.86	1.32	1.10	-4.82	0.0000 **
Inside an egg	117	3.32	3.25	1.26	1.23	0.63	0.5365
Development of chick	118	3.13	3.51	1.29	1.20	-2.99	0.00295 **

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (g) of advantaged learners expressing even satisfaction with the overall impression of the illustration than sample (c) of the disadvantaged learners.

Table 4.15 (d) Summary of the results of the 251 disadvantaged (Nd) vs. 194 advantaged learners (Nh) with regard to satisfaction with the **overall impression** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nd = 251) Disadvantaged***	***Mean Group 2 (Nh =194)) Advantaged***	***SD (d)***	***SD (h)***	***t-value***	***p-value***
Days of big rain	145	3.32	3.31	1.18	1.06	0.09	0.9288
Water cycle	146	3.63	3.74	1.24	1.16	-0.95	0.3416
Penguins in peril	151	2.68	2.77	1.20	1.07	-0.83	0.4052
Penguins	152	3.34	3.50	1.28	1.19	-1.36	0.1746
Jackass penguins	153	3.36	3.34	1.23	1.13	0.21	0.8352
Kelp gulls	154	3.32	3.30	1.31	1.16	0.13	0.8945
Kelp gull feeding	155	2.85	2.94	1.26	1.20	-0.74	0.4604
Hippos	157	2.61	2.59	1.24	1.14	0.14	0.8899
Mussels	164	2.66	3.09	1.30	1.23	-3.56	0.00042 **
Platannas	166	2.86	2.89	1.34	1.29	-0.24	0.8084

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the sample (h) of advantaged learners expressing more satisfaction with the overall impression of the illustration than sample (d) of the disadvantaged learners.

Table 4.16 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	2.88	2.61	1.02	1.07	2.45	0.0147 *
Dinosaurs	26	2.96	2.83	1.11	1.11	1.13	0.2600
Properties of water	27	2.95	2.94	1.14	1.19	0.07	0.9440
Lake	29	3.24	3.11	1.17	1.13	1.07	0.2857
Greenhouse effect	34	2.89	2.84	1.20	1.20	0.39	0.6953
Squid hunting	37	3.41	3.36	1.17	1.16	0.41	0.6840
Water	38	3.23	2.89	1.14	1.17	2.80	0.005 **
Warming up water	40	3.08	2.89	1.11	1.07	1.64	0.1029
Foundation of earth	44	3.68	3.64	1.19	1.23	0.36	0.7192
Shape of things	47	3.14	2.89	1.23	1.09	2.04	0.0418 *

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nk being more satisfied than the Grade 9 sample No

University of Cape Town

Table 4.16 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nl = 219) Grade 8*	*Mean Group 2 (Np = 196) Grade 9*	*SD (l)*	*SD (p)*	*t-value*	*p-value*
Flea	1	2.87	2.95	1.16	1.05	-0.75	0.4543
Flea sucking	2	3.41	3.61	1.10	1.23	-1.72	0.0868
Lamp	3	2.94	3.34	1.19	1.06	-3.57	0.0004 **
Fly	5	3.96	4.02	1.20	1.16	-0.53	0.5955
Swarming locust	7	3.77	3.79	1.15	1.10	-0.21	0.8303
Bees at work	10	3.53	3.53	1.15	1.12	0.01	0.9934
Perlemoen (1)	13	2.51	2.74	1.07	1.06	-2.14	0.0332 *
Perlemoen (2)	14	3.55	3.47	1.19	1.10	0.74	0.4622
Spider's web	20	4.01	3.96	1.22	1.17	0.39	0.6993
Poisonous spiders	23	3.31	3.53	1.14	1.14	-1.96	0.0509

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, , with the Grade 8 sample Nl being less satisfied than the Grade 9 sample Np

University of Cape Town

Table 4.16 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **size** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nm = 220) Grade 8*	*Mean Group 2 (Nq = 196) Grade 9*	*SD (m)*	*SD (q)*	*t-value*	*p-value*
Gull in flight	97	2.83	2.83	0.98	0.91	0.01	0.9917
Penguin	98	3.08	2.66	0.96	1.47	3.91	0.0001 **
Sunbird	99	3.32	3.48	0.98	1.06	-1.60	0.1096
Chicken	100	2.56	2.31	1.04	0.99	2.44	0.0152 *
Flight into danger	103	3.34	3.13	0.99	1.13	1.99	0.0478 *
Owl	107	3.72	3.74	1.03	0.93	-0.21	0.8349
Flying fishermen	109	3.15	2.79	0.99	1.04	1.75	0.0816
Ostrich	116	3.60	3.70	1.13	1.03	0.95	0.3442
Inside an egg	117	3.41	3.51	1.03	1.06	-0.97	0.3353
Development of chick	118	3.27	3.25	1.16	1.13	0.14	0.8897

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, , with the Grade 8 sample Nm being more satisfied than the Grade 9 sample Nq

University of Cape Town

Table 4.16 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **size** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nn = 205) Grade 8***	***Mean Group 2 (Nr = 212) Grade 9***	***SD (n)***	***SD (r)***	***t-value***	***p-value***
Days of big rain	145	2.48	2.31	0.95	1.00	1.82	0.0691
Water cycle	146	3.86	3.57	1.00	1.09	2.91	0.0038 **
Penguins in peril	151	2.84	2.66	1.01	1.07	1.90	0.0581
Penguins	152	3.53	3.33	1.08	1.03	2.06	0.0400 *
Jackass penguins	153	3.28	3.35	1.03	0.95	-0.72	0.4704
Kelp gulls	154	3.18	3.13	1.06	1.07	0.57	0.5709
Kelp gull feeding	155	2.93	2.82	1.25	1.15	0.96	0.3371
Hippos	157	2.32	2.38	0.98	1.13	-0.53	0.6000
Mussels	164	2.94	2.82	1.19	1.24	1.03	0.3048
Platannas	166	2.98	2.94	1.16	1.24	0.30	0.7680

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the Grade 8 sample Nn being more satisfied than the Grade 9 sample Nr

University of Cape Town

Table 4.17 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 (No) with regard to the perception of the **clearness** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	3.24	2.79	1.12	0.97	-4.07	0.0000 **
Dinosaurs	26	3.81	3.40	1.26	1.17	3.22	0.0014 **
Properties of water	27	3.67	3.65	1.26	1.28	0.09	0.9250
Lake	29	3.81	3.63	1.27	1.19	1.46	0.1441
Greenhouse effect	34	3.42	3.40	1.37	1.26	0.16	0.8735
Squid hunting	37	3.37	3.28	1.31	1.23	0.64	0.5216
Water	38	3.56	3.27	1.27	1.33	2.12	0.0346 *
Warming up water	40	3.58	3.38	1.23	1.23	1.52	0.1284
Foundation of earth	44	3.82	3.89	1.26	1.17	-0.54	0.5906
Shape of things	47	3.56	3.31	1.28	1.22	1.95	0.0522

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, , with the Grade 8 sample Nk being more satisfied than the Grade 9 sample No

University of Cape Town

Table 4.17 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **clearness** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nl = 219) Grade 8***	***Mean Group 2 (Np = 196) Grade 9***	***SD (l)***	***SD (p)***	***t-value***	***p-value***
Flea	1	3.06	3.47	1.13	1.10	-3.56	0.0004 **
Flea sucking	2	3.41	3.61	1.41	1.29	-1.52	0.1296
Lamp	3	3.73	3.62	3.94	1.28	0.35	0.7242
Fly	5	4.23	4.26	1.05	1.13	-0.36	0.7212
Swarming locust	7	4.04	4.32	1.25	0.99	-2.53	0.0116 *
Bees at work	10	3.95	3.82	1.23	1.17	1.13	0.2576
Perlemoen (1)	13	2.86	3.63	1.26	1.29	-6.17	0.0000 **
Perlemoen (2)	14	3.70	3.74	1.23	1.22	-0.30	0.7621
Spider's web	20	4.31	4.34	1.23	1.08	-0.28	0.7838
Poisonous spiders	23	3.93	4.00	1.25	1.23	-0.57	0.5724

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nl being <u>less satisfied</u> than the Grade 9 sample Np

University of Cape Town

Table 4.17 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **clearness** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nm = 220) Grade 8*	*Mean Group 2 (Nq = 196) Grade 9*	*SD (m)*	*SD (q)*	*t-value*	*p-value*
Gull in flight	97	3.33	3.31	1.01	1.05	0.17	0.8655
Penguin	98	3.31	3.24	1.11	1.11	0.72	0.4748
Sunbird	99	4.19	4.13	1.04	1.11	0.60	0.5464
Chicken	100	2.43	2.26	1.37	2.45	0.88	0.3793
Flight into danger	103	3.53	3.51	1.16	1.12	0.18	0.8596
Owl	107	3.88	4.15	1.18	1.03	-2.44	0.0153 *
Flying fishermen	109	2.99	3.00	1.16	1.09	-0.09	0.9294
Ostrich	116	3.79	4.02	1.14	0.99	-2.14	0.0327 *
Inside an egg	117	3.52	3.54	1.36	1.17	-0.15	0.8787
Development of chick	118	3.47	3.40	1.29	1.21	0.57	0.5699

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nm being evenly satisfied than the Grade 9 sample Nq

University of Cape Town

Table 4.17 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **clearness** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nn = 205) Grade 8*	*Mean Group 2 (Nr = 212) Grade 9*	*SD (n)*	*SD (r)*	*t-value*	*p-value*
Days of big rain	145	3.05	2.85	1.18	0.99	1.97	0.050 *
Water cycle	146	4.11	4.00	1.20	1.14	0.96	0.3382
Penguins in peril	151	2.48	2.45	1.23	1.22	0.27	0.7871
Penguins	152	4.02	4.00	1.04	1.10	0.23	0.8154
Jackass penguins	153	3.95	3.86	1.01	1.13	0.95	0.3437
Kelp gulls	154	3.74	3.67	1.11	1.17	0.69	0.4921
Kelp gull feeding	155	3.51	3.47	1.32	1.22	0.35	0.7281
Hippos	157	2.35	2.43	1.27	1.22	0.69	0.4921
Mussels	164	2.87	2.86	1.30	1.26	0.04	0.9718
Platannas	166	2.92	3.10	1.28	1.21	1.52	0.1305

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the Grade 8 sample Nn being more satisfied than the Grade 9 sample Nr

University of Cape Town

Table 4.18 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **colour** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	2.79	2.72	1.17	1.13	0.59	0.5541
Dinosaurs	26	3.78	3.87	1.22	1.16	-0.68	0.4989
Properties of water	27	3.26	3.38	1.32	1.28	-0.91	0.3649
Lake	29	3.69	3.51	1.31	1.27	1.37	0.1707
Greenhouse effect	34	3.25	3.37	1.28	1.18	-0.96	0.3360
Squid hunting	37	3.21	3.09	1.28	1.22	0.91	0.3619
Water	38	3.01	2.91	1.33	1.33	0.71	0.4771
Warming up water	40	3.29	3.19	1.25	1.18	0.76	0.4479
Foundation of earth	44	3.54	3.49	1.29	1.20	0.35	0.7292
Shape of things	47	2.77	2.82	1.28	1.22	-0.38	0.7065

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nk being more satisfied than the Grade 9 sample No

University of Cape Town

Table 4.18 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **colour** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nl = 219) Grade 8***	***Mean Group 2 (Np = 196) Grade 9***	***SD (l)***	***SD (p)***	***t-value***	***p-value***
Flea	1	3.22	3.35	1.25	1.15	-1.12	0.2654
Flea sucking	2	3.47	3.43	1.25	1.22	0.33	0.7387
Lamp	3	3.36	3.66	1.24	1.13	-2.56	0.0108 **
Fly	5	3.45	3.24	1.24	1.25	1.73	0.0848
Swarming locust	7	4.04	3.88	1.14	1.16	1.44	0.1496
Bees at work	10	3.70	3.32	1.21	1.29	3.13	0.0019 **
Perlemoen (1)	13	3.25	3.22	1.20	1.16	0.23	0.8162
Perlemoen (2)	14	3.47	3.40	1.19	1.14	0.65	0.5164
Spider's web	20	4.04	4.12	1.29	1.04	0.69	0.4901
Poisonous Spiders	23	3.87	3.90	1.19	1.22	-0.23	0.8156

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nl being more satisfied than the Grade 9 sample Np

University of Cape Town

Table 4.18 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **colour** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nm = 220) Grade 8***	***Mean Group 2 (Nq = 196) Grade 9***	***SD (m)***	***SD (q)***	***t-value***	***p-value***
Gull in flight	97	3.59	3.19	1.17	1.12	3.50	0.0005 **
Penguin	98	3.40	3.11	1.25	1.11	2.46	0.014 *
Sunbird	99	4.23	3.87	1.03	1.05	3.44	0.0006 **
Chicken	100	1.88	2.81	1.26	1.65	-6.31	0.0000 **
Flight into danger	103	3.56	2.59	1.21	1.35	7.61	0.0000 **
Owl	107	3.85	3.61	1.14	1.13	2.13	0.034 *
Flying fishermen	109	3.09	3.36	1.16	1.26	-2.19	0.0293 *
Ostrich	116	3.70	3.16	1.08	1.17	4.79	0.0000 **
Inside an egg	117	3.15	3.35	1.14	1.17	-1.74	0.0829
Development of chick	118	3.06	3.19	1.33	1.14	-1.09	0.2760

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nm being more satisfied than the Grade 9 sample Nq

University of Cape Town

Table 4.18 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **colour** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nn = 205) Grade 8***	***Mean Group 2 (Nr = 212) Grade 9***	***SD (n)***	***SD (r)***	***t-value***	***p-value***
Days of big Rain	145	3.54	3.54	1.20	1.09	0.02	0.9869
Water cycle	146	4.20	3.96	0.99	1.13	2.34	0.0197 *
Penguins in peril	151	2.55	2.46	1.23	1.17	0.81	0.421
Penguins	152	3.85	3.67	1.07	1.14	1.67	0.0949
Jackass penguins	153	3.75	3.72	1.11	1.06	0.22	0.8254
Kelp gulls	154	3.58	3.65	1.12	1.10	-0.61	0.5448
Kelp gull Feeding	155	3.28	3.36	1.25	1.15	-0.69	0.4931
Hippos	157	2.41	2.34	1.18	1.15	0.61	0.5418
Mussels	164	2.61	2.53	1.25	1.27	0.65	0.5192
Platannas	166	2.64	2.72	1.26	1.18	-0.76	0.4499

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the Grade 8 sample Nn being more satisfied than the Grade 9 sample Nr

University of Cape Town

Table 4.19 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **relevance to the text**.

Drawing	***Page***	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	2.86	2.77	1.15	1.23	0.75	0.4534
Dinosaurs	26	2.80	2.74	1.21	1.17	0.49	0.6242
Properties of water	27	2.97	3.18	1.25	1.17	-1.67	0.0952
Lake	29	2.85	2.83	1.12	1.12	0.19	0.8532
Greenhouse effect	34	3.03	3.13	1.18	1.22	-0.83	0.4098
Squid hunting	37	2.85	2.94	1.12	1.17	-0.77	0.4443
Water	38	2.95	2.96	1.22	1.27	-0.04	0.9683
Warming up water	40	3.03	2.93	1.13	1.15	0.82	0.4120
Foundation of earth	44	3.20	3.24	1.32	1.21	-0.25	0.7995
Shape of things	47	3.05	2.78	1.11	1.18	2.32	0.0208 *

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nk being evenly satisfied than the Grade 9 sample No

University of Cape Town

Table 4.19 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **relevance to the text**.

Drawing	***Page***	***Mean Group 1 (Nl = 219) Grade 8***	***Mean Group 2 (Np = 196) Grade 9***	***SD (l)***	***SD (p)***	***t-value***	***p-value***
Flea	1	2.95	3.01	1.27	1.22	-0.49	0.6255
Flea sucking	2	2.73	3.15	1.23	1.18	-3.61	0.0003 **
Lamp	3	3.04	3.10	1.22	1.07	-0.54	0.5923
Fly	5	3.26	3.13	1.21	1.13	1.11	0.2677
Swarming locust	7	3.19	3.13	1.07	1.23	0.53	0.5994
Bees at work	10	3.47	3.02	1.19	1.21	3.87	0.0001 **
Perlemoen (1)	13	3.14	3.11	1.19	1.22	0.21	0.8349
Perlemoen (2)	14	3.20	3.05	1.18	1.16	1.26	0.2083
Spider's web	20	3.34	3.26	1.24	1.25	0.72	0.4746
Poisonous spiders	23	3.22	3.14	1.26	1.26	0.69	0.4879

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nl being more satisfied than the Grade 9 sample Np

University of Cape Town

Table 4.19 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **relevance to the text**.

Drawing	*Page*	***Mean Group 1 (Nm = 220) Grade 8***	***Mean Group 2 (Nq = 196) Grade 9***	***SD (m)***	***SD (q)***	***t-value***	***p-value***
Gull in flight	97	3.12	2.81	1.19	1.01	2.81	0.0052 **
Penguin	98	2.87	3.09	1.05	1.07	-2.02	0.0442 *
Sunbird	99	3.24	3.30	1.13	1.12	-0.50	0.6210
Chicken	100	2.66	2.66	1.18	1.11	0.01	0.9905
Flight into danger	103	3.12	3.08	1.10	1.01	0.44	0.6639
Owl	107	3.14	3.29	1.17	1.13	-1.38	0.1690
Flying fishermen	109	2.84	2.75	1.06	1.07	0.83	0.4077
Ostrich	116	3.19	3.29	1.09	1.10	-0.95	0.3407
Inside an egg	117	3.02	3.18	1.19	1.14	-1.41	0.1604
Development of chick	118	3.18	3.08	1.30	1.18	0.76	0.4464

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nm being less satisfied than the Grade 9 sample Nq

University of Cape Town

Table 4.19 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **relevance to the text**.

Drawing	*Page*	*Mean Group 1 (Nn = 205) Grade 8*	*Mean Group 2 (Nr = 212) Grade 9*	*SD (n)*	*SD (r)*	*t-value*	*p-value*
Days of big rain	145	2.81	3.03	1.23	1.22	-1.88	0.0605
Water cycle	146	3.21	3.27	1.09	1.16	-0.56	0.5772
Penguins in peril	151	2.77	2.77	1.21	1.07	0.06	0.9518
Penguins	152	2.99	3.03	1.14	1.13	-0.33	0.7434
Jackass penguins	153	3.04	3.03	1.23	1.14	0.13	0.8935
Kelp gulls	154	3.02	3.13	1.21	1.11	-1.02	0.3065
Kelp gull feeding	155	2.70	2.71	1.23	1.14	-0.09	0.9289
Hippos	157	2.66	2.81	1.25	1.21	-1.30	0.1938
Mussels	164	2.66	2.58	1.19	1.08	0.78	0.4338
Platannas	166	2.70	2.76	1.22	1.18	-0.55	0.5835

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the Grade 8 sample Nn being <u>less satisfied</u> than the Grade 9 sample Nr

University of Cape Town

Table 4.20 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **suitability for Africa**.

Drawing	***Page***	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	3.03	2.73	1.41	1.39	2.11	0.0350 *
Dinosaurs	26	2.58	2.47	1.30	1.37	0.80	0.4270
Properties of water	27	3.53	3.77	1.40	1.32	-1.71	0.0889
Lake	29	3.50	3.58	1.31	1.23	-0.59	0.5566
Greenhouse effect	34	3.06	3.06	1.32	1.31	0.00	0.9983
Squid hunting	37	2.77	2.81	1.34	1.31	-0.33	0.7439
Water	38	3.37	3.46	1.43	1.29	-0.68	0.4959
Warming up water	40	3.16	3.19	1.33	1.26	-0.18	0.8607
Foundation of earth	44	3.42	3.31	1.36	1.36	0.79	0.4329
Shape of things	47	3.11	3.22	1.33	1.27	-0.78	0.4356

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nk being <u>less satisfied</u> than the Grade 9 sample No

Table 4.20 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **suitability for Africa**.

Drawing	*Page*	***Mean Group 1 (Nl = 219) Grade 8***	***Mean Group 2 (Np = 196) Grade 9***	***SD (l)***	***SD (p)***	***t-value***	***p-value***
Flea	1	3.42	3.11	1.48	1.45	2.23	0.0265 *
Flea sucking	2	3.55	3.32	1.35	1.37	1.79	0.0745
Lamp	3	3.69	3.56	1.27	1.31	1.02	0.3098
Fly	5	3.84	3.65	1.23	1.30	1.55	0.1213
Swarming locust	7	3.83	3.56	1.28	1.33	2.20	0.0285 *
Bees at work	10	3.96	3.70	1.17	1.28	2.25	0.0247 *
Perlemoen (1)	13	3.79	3.01	1.30	1.27	4.15	0.00004 **
Perlemoen (2)	14	4.05	3.31	1.05	1.30	6.66	0.00000 **
Spider's web	20	3.95	3.61	1.26	1.41	2.67	0.0079 **
Poisonous spiders	23	3.77	3.45	1.29	1.36	2.54	0.0114 *

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nl being more satisfied than the Grade 9 sample Np

University of Cape Town

Table 4.20 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **suitability for Africa**.

Drawing	***Page***	***Mean Group 1 (Nm = 220) Grade 8***	***Mean Group 2 (Nq = 196) Grade 9***	***SD (m)***	***SD (q)***	***t-value***	***p-value***
Gull in flight	97	3.69	3.84	1.26	1.26	-1.16	0.2481
Penguin	98	3.23	3.67	1.32	1.27	-3.37	0.00008 **
Sunbird	99	3.62	3.79	1.16	1.12	-1.51	0.1315
Chicken	100	3.33	3.81	1.46	1.18	-3.57	0.0004 **
Flight into Danger	103	3.36	3.23	1.31	1.21	0.97	0.3305
Owl	107	3.36	3.26	1.28	1.29	0.72	0.4724
Flying fishermen	109	2.94	3.03	1.19	1.17	-0.76	0.4502
Ostrich	116	3.68	3.77	1.18	1.24	-0.74	0.4630
Inside an Egg	117	3.38	3.57	1.25	1.06	-1.52	0.1284
Development of chick	118	3.53	3.49	1.27	1.22	0.32	0.7514

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nm being <u>less satisfied</u> than the Grade 9 sample Nq

Table 4.20 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **suitability for Africa**.

Drawing	***Page***	***Mean Group 1 (Nn = 205) Grade 8***	***Mean Group 2 (Nr = 212) Grade 9***	***SD (n)***	***SD (r)***	***t-value***	***p-value***
Days of big rain	145	3.29	3.38	1.44	1.39	-0.68	0.4973
Water cycle	146	3.65	3.62	1.35	1.32	0.28	0.7793
Penguins in peril	151	2.89	2.88	1.46	1.22	0.06	0.9488
Penguins	152	3.39	3.25	1.35	1.20	1.20	0.2292
Jackass penguins	153	3.24	3.20	1.40	1.25	0.26	0.7918
Kelp gulls	154	3.27	3.18	1.37	1.25	0.73	0.4670
Kelp gull feeding	155	3.11	2.76	1.32	1.23	2.90	0.0039 **
Hippos	157	2.71	2.63	1.38	1.27	0.61	0.5442
Mussels	164	3.01	2.82	1.35	1.36	1.42	0.1571
Platannas	166	2.81	2.73	1.35	1.30	0.59	0.5537

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the Grade 8 sample Nn being more satisfied than the Grade 9 sample Nr

University of Cape Town

Table 4.21 (a) Summary of the results of the 182 Grade 8 (Nk) vs. 187 Grade 9 learners (No) with regard to the perception of the **overall impression** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nk = 182) Grade 8***	***Mean Group 2 (No = 187) Grade 9***	***SD (k)***	***SD (o)***	***t-value***	***p-value***
Asteroid	25	3.18	2.72	1.15	1.12	3.90	0.0001 **
Dinosaurs	26	3.12	2.98	1.22	1.24	1.13	0.2574
Properties of water	27	3.42	3.37	1.32	1.19	0.40	0.6908
Lake	29	3.38	3.25	1.22	1.20	1.01	0.3123
Greenhouse effect	34	3.22	2.96	1.31	1.28	1.90	0.0586
Squid hunting	37	2.98	2.93	1.29	1.28	0.38	0.7042
Water	38	3.18	2.92	1.23	1.30	1.92	0.0559
Warming up water	40	3.01	2.85	1.24	1.23	1.22	0.2233
Foundation of earth	44	3.41	3.30	1.31	1.40	0.78	0.4385
Shape of things	47	3.10	2.80	1.32	1.30	2.19	0.0289 *

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nk being more satisfied than the Grade 9 sample No

Table 4.21 (b) Summary of the results of the 219 Grade 8 (Nl) vs. 196 Grade 9 learners (Np) with regard to the perception of the **overall impression** of the illustrations.

Drawing	*Page*	***Mean Group 1 (Nl = 219) Grade 8***	***Mean Group 2 (Np = 196) Grade 9***	***SD (l)***	***SD (p)***	***t-value***	***p-value***
Flea	1	3.10	3.24	1.27	1.11	-1.19	0.2359
Flea sucking	2	3.05	3.19	1.25	1.12	-1.28	0.2031
Lamp	3	3.55	3.39	1.24	1.20	1.33	0.1831
Fly	5	3.70	3.57	1.35	1.28	0.98	0.3256
Swarming locust	7	3.50	3.48	1.33	1.19	0.19	0.8536
Bees at work	10	3.54	3.25	1.25	1.30	2.31	0.0214 *
Perlemoen (1)	13	2.84	3.10	1.36	1.20	-2.03	0.0425 *
Perlemoen (2)	14	3.46	3.30	1.43	1.20	1.20	0.2324
Spider's web	20	3.73	3.53	1.47	1.31	1.41	0.1477
Poisonous spiders	23	3.43	3.39	1.47	1.39	0.30	0.7669

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nl being more satisfied than the Grade 9 sample Np

University of Cape Town

Table 4.21 (c) Summary of the results of the 220 Grade 8 (Nm) vs. 232 Grade 9 learners (Nq) with regard to the perception of the **overall impression** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Nm = 220) Grade 8*	*Mean Group 2 (Nq = 196) Grade 9*	*SD (m)*	*SD (q)*	*t-value*	*p-value*
Gull in flight	97	3.35	3.42	1.07	1.17	-0.67	0.5039
Penguin	98	3.31	3.34	0.99	1.01	-0.30	0.7666
Sunbird	99	3.48	3.94	1.21	1.14	-3.90	0.0001 **
Chicken	100	2.59	2.42	1.21	1.31	1.35	0.1787
Flight into danger	103	3.21	3.34	1.24	1.19	-1.08	0.2821
Owl	107	3.38	3.65	1.14	1.25	-2.31	0.0214 *
Flying fishermen	109	3.01	2.99	1.15	1.31	0.16	0.8711
Ostrich	116	3.31	3.69	1.19	1.32	-3.03	0.0026 **
Inside an egg	117	3.37	3.21	1.19	1.30	1.23	0.2179
Development of chick	118	3.32	3.25	1.21	1.33	0.58	0.5621

University of Cape Town

** $p < 0.01$ shows highly significant differences between samples 1 and 2

* $p < 0.05$ shows significant differences between samples 1 and 2, with the Grade 8 sample Nm being less satisfied than the Grade 9 sample Nq

Table 4.21 (d) Summary of the results of the 205 Grade 8 (Nn) vs. 212 Grade 9 learners (Nr) with regard to the perception of the **overall impression** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Nn = 205) Grade 8***	***Mean Group 2 (Nr = 212) Grade 9***	***SD (n)***	***SD (r)***	***t-value***	***p-value***
Days of big rain	145	3.26	3.80	1.15	1.10	-1.18	0.2384
Water cycle	146	3.67	3.69	1.22	1.90	-023	0.8184
Penguins in peril	151	2.66	2.77	1.18	1.10	-097	0.3305
Penguins	152	3.37	2.77	1.31	1.10	-5.31	0.0000 **
Jackass penguins	153	3.41	3.29	1.20	1.17	1.07	0.2867
Kelp gulls	154	3.34	3.29	1.27	1.22	0.41	0.6821
Kelp gull feeding	155	2.80	2.97	1.19	1.28	-1.45	0.1469
Hippos	157	2.58	2.62	1.24	1.16	-0.33	0.7456
Mussels	164	2.83	2.86	1.26	1.31	-0.24	0.8134
Platannas	166	2.80	2.94	1.32	1.32	-1.12	0.2644

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the Grade 8 sample Nn being less satisfied than the Grade 9 sample Nr

University of Cape Town

Table 4.22 (a) Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HST) or primary school (PST) teachers with regard to the **size** of the illustrations.

Drawing	*Group vs. Group*		*Valid N*	*Valid N*	*Mean*	*Mean*	*SD*	*SD*	*t-value*	*p-value*
	1	*2*	*Group 1*	*Group 2*	*Group 1*	*Group 2*	*Group 1*	*Group 2*		
Days of big rain	A	HST	200	29	2.31	1.79	0.98	0.62	2.76	0.0062 **
	A	PST	200	35	2.31	1.66	0.98	0.54	3.84	0.0002 **
	D	HST	252	29	2.46	1.79	0.97	0.62	3.59	0.0004 **
	D	PST	252	35	2.46	1.66	0.97	0.54	4.76	0.0000 **
Water cycle	A	HST	200	29	3.78	3.52	1.07	0.74	1.22	0.2291
	A	PST	200	35	3.78	3.74	1.07	0.74	0.17	0.8645
	D	HST	252	29	3.66	3.52	1.04	0.74	0.73	0.4641
	D	PST	252	35	3.66	3.74	1.04	0.74	-0.44	0.6594
Penguins in peril	A	HST	200	29	2.77	2.76	1.07	0.95	0.05	0.9569
	A	PST	200	35	2.77	2.86	1.07	1.03	-0.45	0.6565
	D	HST	252	29	2.73	2.76	1.02	0.95	-0.16	0.8702
	D	PST	252	35	2.73	2.86	1.02	1.03	-0.71	0.4771
Penguins	A	HST	200	29	3.44	3.21	1.03	0.86	1.14	0.2552
	A	PST	200	35	3.44	3.23	1.03	0.84	1.13	0.2614
	D	HST	200	35	3.42	3.21	1.09	0.86	1.02	0.3068
	D	PST	200	35	3.42	3.23	1.09	0.84	1.01	0.3155
Jackass penguins	A	HST	200	29	3.48	2.55	0.98	0.73	4.89	0.0000 **
	A	PST	200	35	3.48	2.97	0.98	0.95	2.84	0.0049 **
	D	HST	252	29	3.19	2.55	0.98	0.73	3.38	0.0008 **
	D	PST	252	35	3.19	2.97	0.98	0.95	1.22	0.2226

** $p < 0.01$ shows highly significant differences between sample 1 and 2

University of Cape Town

Table 4.22 (cont.)

Drawing	*Group vs 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Kelp gulls	A	HST	200	28	3.22	3.07	1.05	0.88	0.74	0.4626
	A	PST	200	35	3.22	3.11	1.05	0.83	0.56	0.5733
	D	HST	250	28	3.10	3.07	1.07	0.88	0.15	0.8839
	D	PST	250	35	3.10	3.11	1.07	0.83	0.08	0.9364
Kelp gull feeding	A	HST	200	28	3.02	2.62	1.22	0.78	1.72	0.0872
	A	PST	200	35	3.02	2.74	1.22	0.92	1.29	0.1999
	D	HST	250	28	2.75	2.62	1.17	0.78	0.56	0.5733
	D	PST	250	35	2.75	2.74	1.17	0.92	0.02	0.9877
Hippos	A	HST	200	28	2.46	1.62	1.04	0.68	4.21	0.000**
	A	PST	200	35	2.46	2.17	1.04	0.89	1.54	0.1241
	D	HST	250	28	2.26	1.62	1.07	0.68	3.17	0.01 **
	D	PST	250	35	2.26	2.17	1.07	0.89	0.48	0.6319
Mussels	A	HST	200	28	3.10	2.45	1.20	0.78	2.82	0.01 **
	A	PST	200	35	3.10	2.86	1.20	0.81	1.13	0.2596
	D	HST	250	28	2.70	2.45	1.20	0.78	1.11	0.2677
	D	PST	250	35	2.70	2.86	1.20	0.81	0.74	0.4610
Platanna	A	HST	200	28	3.13	2.86	1.19	0.92	1.14	0.2550
	A	PST	200	35	3.13	2.63	1.19	0.84	2.36	0.02 **
	D	HST	250	28	2.83	2.86	1.19	0.92	0.14	0.8863
	D	PST	250	35	2.83	2.63	1.19	0.84	0.96	0.3358

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.23 Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HS) or primary school (PS) teachers with regard to **the clearness** of the illustrations.

Drawing	*Group vs. Group 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Days of big rain	A	HST	200	28	2.83	2.14	1.03	0.83	3.44	0.0007 **
	A	PST	200	35	2.83	2.14	1.03	0.43	3.86	0.0002 **
	D	HST	250	28	3.07	2.14	1.12	0.83	4.31	0.0000 **
	D	PST	250	35	3.07	2.14	1.12	0.43	4.83	0.0000 **
Water cycle	A	HST	200	28	3.97	3.69	1.21	0.89	1.18	0.2407
	A	PST	200	35	3.97	3.86	1.21	0.94	0.50	0.6180
	D	HST	250	28	4.12	3.69	1.13	0.89	1.97	0.050 *
	D	PST	250	35	4.12	3.86	1.13	0.94	1.31	0.1918
Penguins in peril	A	HST	200	28	2.42	2.55	1.26	1.09	-0.55	0.5529
	A	PST	200	35	2.42	2.40	1.26	0.95	0.08	0.9389
	D	HST	250	28	2.51	2.55	1.20	1.09	-0.19	0.8515
	D	PST	250	35	2.51	2.40	1.20	0.95	0.51	0.6101
Penguins	A	HST	200	28	4.06	3.66	1.00	0.90	2.05	0.0417 *
	A	PST	200	35	4.06	3.26	1.00	1.01	4.36	0.0000 **
	D	HST	250	28	3.80	3.66	1.13	0.90	1.49	0.1379
	D	PST	250	35	3.80	3.26	1.13	1.01	3.59	0.0004 **
Jackass penguins	A	HST	200	28	4.03	3.28	1.10	1.03	3.49	0.0006 **
	A	PST	200	35	4.03	3.20	1.10	0.99	4.19	0.0000 **
	D	HST	250	28	3.80	3.28	1.05	1.03	2.57	0.0106 *
	D	PST	250	35	3.80	3.20	1.05	0.99	3.21	0.0015 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.23 (cont.)

Drawing	*Group vs. Group 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Kelp gulls	A	HST	200	28	3.71	3.24	1.23	1.09	0.94	0.0539
	A	PST	200	35	3.71	3.17	1.23	0.92	2.46	0.0145 *
	D	HST	250	28	3.66	3.24	1.11	1.09	0.95	0.0518
	D	PST	250	35	3.66	3.17	1.11	0.92	2.52	0.0124 *
Kelp gull feeding	A	HST	200	28	3.72	2.83	1.19	1.14	3.83	0.0002 **
	A	PST	200	35	3.72	3.29	1.19	0.86	2.09	0.0376 *
	D	HST	250	28	3.30	2.83	1.30	1.14	1.89	0.0602
	D	PST	250	35	3.30	3.29	1.30	0.86	0.08	0.9359
Hippos	A	HST	200	28	2.44	1.69	1.25	0.76	3.17	0.0018 **
	A	PST	200	35	2.44	1.74	1.25	0.82	3.20	0.0016 **
	D	HST	250	28	2.35	1.69	1.24	0.76	2.81	0.0054 **
	D	PST	250	35	2.35	1.74	1.24	0.82	2.81	0.0053 **
Mussels	A	HST	200	28	3.03	1.93	1.28	0.70	4.54	0.0000 **
	A	PST	200	35	3.03	2.34	1.28	0.97	3.04	0.0027 **
	D	HST	250	28	2.73	1.93	1.28	0.70	3.32	0.0010 **
	D	PST	250	35	2.73	2.34	1.28	0.97	1.74	0.0838
Platannas	A	HST	200	28	3.01	2.69	1.18	1.17	1.37	0.1726
	A	PST	200	35	3.01	2.26	1.18	0.89	3.60	0.0004 **
	D	HST	250	28	3.02	2.69	1.30	1.17	1.30	0.1959
	D	PST	250	35	3.02	2.26	1.30	0.89	3.36	0.0009 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.24 Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HS) or primary school (PS) teachers with regard to the **colour** of the illustrations.

Drawing	*Group vs. Group* 1	2	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Days of big rain	A	HST	200	28	3.50	2.39	1.14	0.99	4.87	0.0000 **
	A	PST	200	35	3.50	2.89	1.14	0.80	3.04	0.0000 **
	D	HST	250	28	3.58	2.39	1.15	0.99	5.22	0.0000 **
	D	PST	250	35	3.58	2.89	1.15	0.80	3.43	0.0007 **
Water cycle	A	HST	200	28	4.24	3.68	0.85	0.86	3.26	0.0013 **
	A	PST	200	35	4.24	4.00	0.85	0.64	1.60	0.1118
	D	HST	250	28	4.13	3.68	1.03	0.86	2.22	0.0274
	D	PST	250	35	4.13	4.00	1.03	0.64	0.71	0.500
Penguins in peril	A	HST	200	28	2.36	2.07	1.17	0.66	1.28	0.2017
	A	PST	200	35	2.36	2.17	1.17	0.92	0.91	0.3646
	D	HST	250	28	2.61	2.07	1.22	0.66	2.30	0.0221 *
	D	PST	250	35	2.61	2.17	1.22	0.92	2.05	0.0413 *
Penguins	A	HST	200	28	3.81	3.57	1.12	0.96	1.05	0.2945
	A	PST	200	35	3.81	3.06	1.12	0.97	3.72	0.0003 **
	D	HST	250	28	3.72	3.57	1.10	0.96	0.67	0.5098
	D	PST	250	35	3.72	3.06	1.10	0.97	3.37	0.0009 **
Jackass penguins	A	HST	200	28	3.81	3.11	1.04	0.92	3.36	0.0009 **
	A	PST	200	35	3.81	3.14	1.04	0.85	3.55	0.0005 **
	D	HST	250	28	3.68	3.11	1.10	0.92	2.63	0.009 **
	D	PST	250	35	3.68	3.14	1.10	0.85	2.75	0.006 **

** $p < 0,01$ shows highly significant differences between sample 1 and 2

University of Cape Town

Table 4.24 (Cont.)

Drawing	*Group vs. Group 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Kelp gulls	A	HST	200	28	3.00	3.07	1.23	1.05	0.31	0.7538
	A	PST	200	35	3.00	3.03	1.23	0.89	0.16	0.877
	D	HST	250	28	3.58	3.07	1.13	1.05	2.28	0.0237 *
	D	PST	250	35	3.58	3.03	1.13	0.89	2.77	0.005 **
Kelp gull feeding	A	HST	200	28	3.08	2.89	1.38	0.96	0.69	0.4883
	A	PST	200	35	3.08	2.97	1.38	1.01	0.45	0.6569
	D	HST	250	28	3.17	2.89	1.20	0.96	1.18	0.2377
	D	PST	250	35	3.17	2.97	1.20	1.01	0.94	0.3493
Hippos	A	HST	200	28	2.53	1.61	1.17	0.63	4.08	0.0001 **
	A	PST	200	35	2.53	1.69	1.17	0.72	4.12	0.0001 **
	D	HST	250	28	2.35	1.61	1.16	0.63	3.30	0.001 **
	D	PST	250	35	2.35	1.69	1.16	0.72	3.27	0.001 **
Mussels	A	HST	200	28	2.65	1.86	1.30	0.76	3.15	0.002 **
	A	PST	200	35	2.65	2.17	1.30	0.98	2.08	0.0389 *
	D	HST	250	28	2.51	1.86	1.23	0.76	2.74	0.007 **
	D	PST	250	35	2.51	2.17	1.23	0.98	1.54	0.1238
Platannas	A	HST	200	28	2.62	2.54	1.14	1.00	0.35	0.7273
	A	PST	200	35	2.62	2.09	1.14	0.87	2.57	0.011 *
	D	HST	250	28	2.73	2.54	1.27	1.00	0.80	0.4273
	D	PST	250	35	2.73	2.09	1.27	0.87	2.87	0.0044 **

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.25 Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HS) or primary school (PS) teachers with regard to the **relevance to the text**.

Drawing	*Group vs. Group 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Days of big rain	A	HST	200	28	2.98	2.89	1.18	1.07	0.35	0.7266
	A	PST	200	35	2.98	2.63	1.18	0.81	1.68	0.0954
	D	HST	250	28	2.88	2.89	1.27	1.07	0.07	0.9476
	D	PST	250	35	2.88	2.63	1.27	0.81	1.13	0.2614
Water cycle	A	HST	200	28	3.24	3.96	1.06	0.75	3.50	0.0001 **
	A	PST	200	35	3.24	3.63	1.06	0.91	2.05	0.0420 *
	D	HST	250	28	3.24	3.96	1.18	0.75	3.17	0.0017 **
	D	PST	250	35	3.24	3.63	1.18	0.91	1.87	0.0623
Penguins in peril	A	HST	200	28	2.90	3.04	1.06	0.84	-0.65	0.5155
	A	PST	200	35	2.90	3.11	1.06	1.18	-1.09	0.2780
	D	HST	250	28	2.67	3.04	1.19	0.84	-1.60	0.1112
	D	PST	250	35	2.67	3.11	1.19	1.18	-2.09	0.0377 *
Penguins	A	HST	200	28	3.17	3.39	1.10	0.83	-1.05	0.0938
	A	PST	200	35	3.17	3.00	1.10	1.00	-0.83	0.4085
	D	HST	250	28	2.89	3.39	1.14	0.83	-2.28	0.0237 *
	D	PST	250	35	2.89	3.00	1.14	1.00	-0.57	0.5719
Jackass penguins	A	HST	200	28	3.18	3.18	1.08	0.95	-0.02	0.9867
	A	PST	200	35	3.18	2.97	1.08	0.99	1.04	0.2975
	D	HST	250	28	2.92	3.18	1.25	0.95	-1.06	0.2903
	D	PST	250	35	2.92	2.97	1.25	0.99	-0.23	0.8167

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.25 (cont.)

Drawing	*Group vs. 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Kelp gulls	A	HST	200	28	3.21	3.21	1.16	1.18	0.04	0.9677
	A	PST	200	35	3.21	2.91	1.16	0.82	1.42	0.1573
	D	HST	250	28	2.96	3.21	1.18	1.18	1.09	0.2779
	D	PST	250	35	2.96	2.91	1.18	0.82	0.24	0.8087
Kelp gull feeding	A	HST	200	28	2.88	3.04	1.17	1.04	-0.69	0.4907
	A	PST	200	35	2.88	2.83	1.17	1.12	0.22	0.8276
	D	HST	250	28	2.57	3.04	1.18	1.04	-2.01	0.046 *
	D	PST	250	35	2.57	2.83	1.18	1.12	-1.22	0.2222
Hippos	A	HST	200	28	2.89	2.18	1.27	0.91	2.87	0.0045 *
	A	PST	200	35	2.89	2.43	1.27	0.95	2.05	0.0411 *
	D	HST	250	28	2.61	2.18	1.19	0.91	1.84	0.0662
	D	PST	250	35	2.61	2.43	1.19	0.95	0.85	0.3987
Mussels	A	HST	200	28	2.70	2.29	1.10	0.54	1.93	0.055
	A	PST	200	35	2.70	2.43	1.10	1.01	1.33	0.1836
	D	HST	250	28	2.56	2.29	1.15	0.54	1.25	0.2118
	D	PST	250	35	2.56	2.43	1.15	1.01	0.65	0.5163
Platannas	A	HST	200	28	2.80	2.86	1.13	0.97	-0.28	0.7815
	A	PST	200	35	2.80	2.79	1.13	0.88	0.004	0.9965
	D	HST	250	28	2.68	2.86	1.25	0.97	0.72	0.4719
	D	PST	250	35	2.68	2.79	1.25	0.88	-0.51	0.6110

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.26 Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HS) or primary school (PS) teachers with regard to the **suitability for Africa**.

Drawing	*Group vs. Group 1*	*2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Days of big rain	A	HST	200	28	3.22	3.25	1.18	0.70	-0.12	0.9022
	A	PST	200	35	3.22	3.06	1.48	0.77	0.62	0.5384
	D	HST	250	28	3.43	3.25	1.35	0.70	0.68	0.4960
	D	PST	250	35	3.43	3.06	1.35	0.77	1.59	0.1141
Water cycle	A	HST	200	28	3.56	3.86	1.36	0.76	-1.13	0.2590
	A	PST	200	35	3.56	3.51	1.36	0.85	0.19	0.8476
	D	HST	250	28	3.69	3.86	1.31	0.76	-0.66	0.5077
	D	PST	250	35	3.69	3.51	1.31	0.85	0.77	0.4450
Penguins in peril	A	HST	200	28	2.97	2.71	1.34	0.85	0.96	0.3370
	A	PST	200	35	2.97	3.26	1.34	1.07	1.23	0.2220
	D	HST	250	28	2.82	2.71	1.34	0.85	0.40	0.6919
	D	PST	250	35	2.82	3.26	1.34	1.07	-1.87	0.0626
Penguins	A	HST	200	28	3.52	3.25	1.19	0.84	1.14	0.2549
	A	PST	200	35	3.52	2.94	1.19	1.24	2.62	0.0095 **
	D	HST	250	28	3.16	3.25	1.32	0.84	0.36	0.7222
	D	PST	250	35	3.16	2.94	1.32	1.24	0.92	0.3595
Jackass penguins	A	HST	200	28	3.39	2.96	1.33	0.75	1.65	0.0999
	A	PST	200	35	3.39	2.86	1.33	1.16	2.10	0.0365 *
	D	HST	250	28	3.08	2.96	1.30	0.75	0.48	0.6334
	D	PST	250	35	3.08	2.86	1.30	1.16	0.86	0.3929

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.26 (Cont.)

Drawing	*Group vs. 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*P-value*
Kelp gulls	A	HST	200	28	3.33	3.04	1.22	0.92	1.21	0.2272
	A	PST	200	35	3.33	2.83	1.22	1.10	2.26	0.0250 *
	D	HST	250	28	3.15	3.04	1.38	0.92	0.42	0.6757
	D	PST	250	35	3.15	2.83	1.38	1.10	1.31	0.1903
Kelp gull feeding	A	HST	200	28	3.04	2.64	1.27	0.91	1.60	0.1107
	A	PST	200	35	3.04	2.54	1.27	0.95	2.21	0.0278 *
	D	HST	250	28	2.84	2.64	1.29	0.91	0.77	0.4413
	D	PST	250	35	2.84	2.54	1.29	0.95	1.30	0.1964
Hippos	A	HST	200	28	2.75	2.50	1.28	0.79	0.99	0.3257
	A	PST	200	35	2.75	3.03	1.28	0.92	1.25	0.2113
	D	HST	250	28	2.60	2.50	1.36	0.79	0.40	0.6916
	D	PST	250	35	2.60	3.03	1.36	0.92	1.79	0.0745
Mussels	A	HST	200	28	3.19	2.57	1.40	0.88	2.29	0.0232 *
	A	PST	200	35	3.19	2.66	1.40	0.97	2.17	0.0307 *
	D	HST	250	28	3.69	2.57	1.28	0.88	0.49	0.6267
	D	PST	250	35	3.69	2.66	1.28	0.97	0.16	0.8766
Platannas	A	HST	200	28	2.89	3.07	1.33	0.98	-0.68	0.4946
	A	PST	200	35	2.89	2.77	1.33	0.96	0.54	0.5911
	D	HST	250	28	2.67	3.07	1.32	0.98	-1.57	0.1169
	D	PST	250	35	2.67	2.77	1.32	0.96	-0.41	0.6795

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.27 Summary of the results of the disadvantaged (D) or advantaged (A) learners vs. high school (HS) or primary school (PS) teachers with regard to the **overall impression**.

Drawing	*Group vs. 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*p-value*
Days of big rain	A	HST	200	28	3.31	2.21	1.06	0.79	5.29	0.0000 **
	A	PST	200	35	3.31	2.23	1.06	0.55	5.91	0.0000 **
	D	HST	250	28	3.32	2.21	1.18	0.79	4.86	0.0000 **
	D	PST	250	35	3.32	2.23	1.18	0.79	4.86	0.0000 **
Water cycle	A	HST	200	28	3.74	3.93	1.16	0.72	-0.83	0.4102
	A	PST	200	35	3.74	3.71	1.16	0.83	0.14	0.8910
	D	HST	250	28	3.63	3.93	1.24	0.72	1.24	0.2166
	D	PST	250	35	3.63	3.71	1.24	0.83	0.38	0.7080
Penguins in peril	A	HST	200	28	2.77	2.79	1.07	0.83	-0.09	0.9316
	A	PST	200	35	2.77	2.66	1.07	0.97	0.57	0.5669
	D	HST	250	28	2.68	2.79	1.20	0.83	-0.47	0.6415
	D	PST	250	35	2.68	2.66	1.20	0.97	0.10	0.9242
Penguins	A	HST	200	28	3.50	3.61	1.19	0.83	-0.48	0.6294
	A	PST	200	35	3.50	3.00	1.19	0.88	2.36	0.0194 *
	D	HST	250	28	3.34	3.61	1.28	0.83	-1.10	0.2725
	D	PST	250	35	3.34	3.00	1.28	0.88	1.50	0.1355
Jackass Penguins	A	HST	200	28	3.34	3.11	1.13	0.79	1.03	0.3050
	A	PST	200	35	3.34	3.06	1.13	0.87	1.38	0.1694
	D	HST	250	28	3.36	3.11	1.23	0.79	1.06	0.2912
	D	PST	250	35	3.36	3.06	1.23	0.87	0.87	0.1622

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.27 (Cont.)

Drawing	*Group vs. Group 1*	*Group 2*	*Valid N Group 1*	*Valid N Group 2*	*Mean Group 1*	*Mean Group 2*	*SD Group 1*	*SD Group 2*	*t-value*	*P-value*
Kelp gulls	A	HST	200	28	3.30	3.18	1.16	0.82	0.55	0.5832
	A	PST	200	35	3.30	3.00	1.16	0.80	1.49	0.1387
	D	HST	250	28	3.32	3.18	1.31	0.82	0.55	0.5800
	D	PST	250	35	3.32	3.00	1.31	0.80	1.40	0.1619
Kelp gull feeding	A	HST	200	28	2.94	3.04	1.20	0.84	0.41	0.6827
	A	PST	200	35	2.94	2.89	1.20	0.90	0.25	0.8016
	D	HST	250	28	2.85	3.04	1.26	0.84	0.75	0.4542
	D	PST	250	35	2.85	2.89	1.26	0.90	0.15	0.8808
Hippos	A	HST	200	28	2.59	1.86	1.14	0.85	3.26	0.0013 **
	A	PST	200	35	2.59	1.94	1.14	0.84	3.20	0.0016 **
	D	HST	250	28	2.61	1.86	1.24	0.85	3.11	0.0021 **
	D	PST	250	35	2.61	1.94	1.24	0.84	3.07	0.0024
Mussels	A	HST	200	28	3.09	2.21	1.23	0.74	3.67	0.0003 **
	A	PST	200	35	3.09	2.31	1.23	0.83	3.59	0.0004 **
	D	HST	250	28	2.66	2.21	1.30	0.74	1.77	0.0772
	D	PST	250	35	2.66	2.31	1.30	0.83	1.52	0.1295
Platannas	A	HST	200	28	2.89	2.93	1.29	0.77	-0.15	0.8816
	A	PST	200	35	2.89	2.27	1.29	0.86	2.72	0.007 **
	D	HST	250	28	2.86	2.93	1.34	0.77	0.26	0.7922
	D	PST	250	35	2.86	2.27	1.34	0.86	2.52	0.0122 *

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2

University of Cape Town

Table 4.28 Summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **size** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Ni = 29) HST***	***Mean Group 2 (Nj = 35) PST***	***SD (i)***	***SD (j)***	***t-value***	***p-value***
Days of big Rain	145	1.79	1.66	0.62	0.54	0.94	0.3517
Water cycle	146	3.52	3.74	0.74	0.74	-1.22	0.2291
Penguins in peril	151	2.76	2.86	0.95	1.03	-0.39	0.6552
Penguins	152	3.21	3.23	0.86	0.84	-0.10	0.9196
Jackass penguins	153	2.55	2.97	0.73	0.95	-1.94	0.0573
Kelp gulls	154	3.07	3.11	0.88	0.83	-0.21	0.8337
Kelp gull Feeding	155	2.62	2.74	0.78	0.92	-0.57	0.5722
Hippos	157	1.62	2.17	0.68	0.89	-2.74	0.0081 **
Mussels	164	2.45	2.86	0.78	0.81	-2.04	0.0455 *
Platannas	166	2.86	2.63	0.92	0.84	1.06	0.2928

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, with the PST sample Nj being more satisfied than the HST sample Ni

University of Cape Town

Table 4.29 Summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of **clearness** of the illustrations.

Drawing	***Page***	***Mean Group 1 (Ni =28) HST***	***Mean Group 2 (Nj = 35) PST***	***SD (i)***	***SD (j)***	***t-value***	***p-value***
Days of big rain	145	2.14	2.14	0.83	0.43	0.03	0.9758
Water cycle	146	3.69	3.86	0.89	0.94	-0.73	0.4713
Penguins in peril	151	2.55	2.40	1.09	0.95	0.60	0.5529
Penguins	152	3.66	3.26	0.90	1.01	1.65	0.1041
Jackass penguins	153	3.28	3.20	1.03	0.99	0.30	0.7661
Kelp gulls	154	3.24	3.17	1.09	0.92	0.28	0.7820
Kelp gull feeding	155	2.83	3.29	1.14	0.86	-1.84	0.0713
Hippos	157	1.69	1.74	0.76	0.82	0.27	0.7900
Mussels	164	1.93	2.34	0.70	0.97	-1.91	0.0609
Platannas	166	2.69	2.26	1.17	0.89	1.68	0.0973

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the PST sample Nj being <u>less satisfied</u> than the HST sample Ni

University of Cape Town

Table 4.30 Summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **colour** of the illustrations.

Drawing	*Page*	*Mean Group 1 (Ni = 29) HST*	*Mean Group 2 (Nj = 35) PST*	*SD (i))*	*SD (j)*	*t-value*	*p-value*
Days of big rain	145	2.39	2.89	0.99	0.80	-2.19	0.0326 *
Water cycle	146	4.00	3.68	0.64	0.86	1.70	0.0951
Penguins in peril	151	2.07	2.17	0.66	0.92	-0.48	0.6314
Penguins	152	3.57	3.06	0.96	0.97	2.10	0.0396 *
Jackass penguins	153	3.11	3.14	0.92	0.85	-0.16	0.8730
Kelp gulls	154	3.07	3.03	1.05	0.89	0.18	0.8616
Kelp gull feeding	155	2.89	2.97	0.96	1.01	-0.31	0.7551
Hippos	157	1.61	1.69	0.63	0.72	0.46	0.6503
Mussels	164	1.86	2.17	0.76	0.99	-1.39	0.1691
Platannas	166	2.54	2.09	1.00	0.87	1.89	0.0637

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the PST sample Nj being more satisfied than the HST sample Ni

Table 4.31 Summary of the results of the 29 high school teachers (HST) vs. 35 primary school teachers (PST) with regard to the perception of the **relevance to the text**.

Drawing	***Page***	***Mean Group 1 (Ni =29) HST***	***Mean Group 2 (Nj = 35) PST***	***SD (i)***	***SD (j)***	***t-value***	***p-value***
Days of big rain	145	2.89	2.63	1.07	0.81	1.12	0.2672
Water cycle	146	3.96	3.63	0.75	0.91	1.58	0.1205
Penguins in peril	151	3.04	3.11	0.84	1.18	-0.30	0.7676
Penguins	152	3.39	3.00	0.83	1.00	1.67	0.1006
Jackass penguins	153	3.18	2.97	0.95	0.99	0.85	0.4017
Kelp gulls	154	3.21	2.91	1.18	0.82	0.37	0.1755
Kelp gull feeding	155	3.04	2.83	1.04	1.12	0.75	0.4548
Hippos	157	2.18	2.43	0.91	0.95	-1.06	0.2929
Mussels	164	2.29	2.43	0.54	1.10	-0.68	0.5011
Platannas	166	2.86	2.79	0.97	0.88	0.27	0.7897

University of Cape Town

Table 4.32 Summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of the **overall impression**.

Drawing	***Page***	***Mean Group 1 (Ni = 28) HST***	***Mean Group 2 (Nj = 35) PST***	***SD (i)***	***SD (j)***	***t-value***	***p-value***
Days of big rain	145	2.21	2.23	0.79	0.55	-0.08	0.9326
Water cycle	146	3.93	3.71	0.72	0.83	1.09	0.2821
Penguins in peril	151	2.79	2.66	0.83	0.97	0.56	0.5797
Penguins	152	3.61	3.00	0.83	0.88	2.80	0.0069 **
Jackass penguins	153	3.11	3.06	0.79	0.87	0.24	0.8142
Kelp gulls	154	3.18	3.00	0.82	0.80	0.87	0.3885
Kelp gull feeding	155	3.04	2.89	0.84	0.90	0.68	0.5006
Hippos	157	1.86	1.94	0.85	0.84	-0.40	0.6897
Mussels	164	2.21	2.31	0.74	0.83	-0.50	0.6203
Platannas	166	2.93	2.27	0.77	0.86	3.17	0.0024 **

University of Cape Town

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the PST sample Nj being less satisfied than the HST sample Ni

Table 4.33 Summary of the results of the 28 high school teachers (HS) vs. 35 primary school teachers (PS) with regard to the perception of the **suitability for Africa**.

Drawing	***Page***	***Mean Group 1 (Ni =29) HST***	***Mean Group 2 (Nj = 35) PST***	***SD (i)***	***SD (j)***	***t-value***	***p-value***
Days of big rain	145	3.25	3.06	0.70	0.77	1.03	0.3061
Water cycle	146	3.86	3.51	0.76	0.85	1.67	0.1008
Penguins in peril	151	2.71	3.26	0.85	1.07	-2.19	0.0325
Penguins	152	3.25	2.94	0.84	1.24	1.12	0.2664
Jackass penguins	153	2.96	2.86	0.75	1.16	0.31	0.7568
Kelp gulls	154	3.04	2.83	0.92	1.10	0.80	0.4280
Kelp gull feeding	155	2.64	2.54	0.91	0.95	0.42	0.6740
Hippos	157	2.50	3.03	0.79	0.92	-2.40	0.0194 *
Mussels	164	2.57	2.66	0.88	0.97	-0.36	0.7174
Platannas	166	3.07	2.77	0.98	0.96	1.24	0.2182

* $p < 0.05$ shows significant differences between samples 1 and 2

** $p < 0.01$ shows highly significant differences between samples 1 and 2, , with the PST sample Nj being <u>less satisfied</u> than the HST sample Ni

University of Cape Town

APPENDIX 4

PHOTOCOPIES OF SOME OF THE RESPONDENTS' REPSONSES

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

   Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	4	3	1	3	4	4	4
146	Water cycle	5	4	1	5	5	5	5
151	Penguins in peril	3	2	1	3	3	3	3
152	Penguins	2	2	1	3	2	3	2
153	Jackass penguins	3	2	1	3	3	3	3
154	Kelp gulls	4	2	1	3	3	2	3
155	Kelp gull feeding	3	2	1	4	4	3	4
157	Hippos	2	2	1	2	3	2	2
164	Mussels	3	3	1	2	3	1	2
166	Platannas	2	2	1	2	3	3	1

2. Now look back at several drawings where your overall impression was the highest (e.g. "5"), and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page 166 highly because

(i) I can see it clearly & it tell me about the thing I live inside in life e.g inside

I rate the drawing on page 145 highly because

(ii) I can't see it clearly but I know this pi... shows me about the... d has dangerous big ... is

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page 157 lowly because

(i) This picture for I can't see it clearly but I know one thing hippo is very dange... to us so we don't need it in our wo...

I rate the drawing on page 166 lowest because

(ii) This one too I can't see it clearly bu... know on thing it is the poisonous dago...

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	No	This is a male birds
153	Jackass Penguins	Yes	I ca
157	Hippos	No	I can't see it clearly
164	Mussels	Yes	I can see it clearly
166	Platannas	No	but I'm not sure.

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	X

AGE	
12- 13 years	
14- 15 years	
16- 17 years	X

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	4	1	5	5	4	2
146	Water cycle	5	3	1	5	5	5	3
151	Penguins in peril	1	3	1	1	3	4	1
152	Penguins	2	3	1	2	1		
153	Jackass penguins	5	3	1	3	5	5	4
154	Kelp gulls	4	4	1	4	5	5	4
155	Kelp gull feeding	2	3	1	5	4	2	2
157	Hippos	1	3	1	1	4	1	1
164	Mussels	3	3	1	4	5	4	2
166	Platannas	2	3	1	4	5	1	2

2. Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page .1.1.1.a.... highly because

(i) he...shows...us...that...he...was...in...
Transkei...are...very...difficult to.....

I rate the drawing on page 1.1.5.. highly because

(ii) he...shows...us...that...was...in...
us...are...the...real...are...fall...in...the...street

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page ..1.5.1..... lowly because

(i) I...dont...like...a...penguins...in...hall...because
it...is...very...dirty.....

I rate the drawing on page ..... lowest because

(ii .....157.....
.....

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	no	
153	Jackass Penguins	yes	
157	Hippos	yes	
164	Mussels	yes	
166	Platannas	yes	

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	✓

AGE	
12- 13 years	
14- 15 years	
16- 17 years	X

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all our life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin GOOD LUCK !!!!

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	4	4 5	2	5	2	5	5
146	Water cycle	5	5	2	5	2	5	3
151	Penguins in peril	2	5	2	5	1	3	1
152	Penguins	5	5	1	5	1	1	1
153	Jackass penguins	4	5	1 2	5	3	5	5
154	Kelp gulls	1	2	1	5	4	4	5
155	Kelp gull feeding	1	2	1	1	1	1	1
157	Hippos	1	1	1	1	1	1	1
154	Mussels	5	3	5	5	1	1	1
156	Platanus	5	5	2	5	4	4	5

University of Cape Town

2. Now look back at several drawings where your overall impression was the highest (e.g "5"), and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page 145 highly because

(i) I like this picture because it is nice truly I like the lightning rain so much and water

I rate the drawing on page 154 highly because

(ii) I like their tea and colour I like this thing because they will help you if you are in trouble and they will give you an advice I like the animals

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page 155 lowly because

(i) I dont like this animal because this animal did not care about another animals and it eat another animal

I rate the drawing on page 157 lowest because

(ii I dont like this animals because it look like a witch and I sked of sorry animal I dont like you.

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	Yes	because they like the public -
153	Jackass Penguins	Yes	because they are same as penguins
157	Hippos	No	because they look like witch
164	Mussels	Yes	I like their colour and is delicious
166	Platannas	Yes	because they walk slowly

Indicate the correct response with a cross (x)

GENDER	
Male	X
Female	

AGE	
12- 13 years	
14- 15 years	X
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

   Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	4	1	5	5	4	2
146	Water cycle	5	3	1	5	5	5	3
151	Penguins in peril	1	3	1	1	3	4	1
152	Penguins	2	3	1	2	1		
153	Jackass penguins	5	3	1	3	5	5	4
154	Kelp gulls	4	4	1	4	5	5	4
155	Kelp gull feeding	2	3	1	5	4	3	3
157	Hippos	1	3	1	1	4	1	1
164	Mussels	3	3	1	4	5	4	3
166	Platannas	2	3	1	4	5	1	2

2. Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page 164 highly because

(i) he drew us that we can't do

Jackis are very difficult to

I rate the drawing on page 164 highly because

(ii) he show us that we can't do

it over the water are fall on the sheet

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page 151 lowly because

(i) I dont like a penguins in hail because

it is very dirty

I rate the drawing on page ..... lowest because

(ii 157

.....

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	no	
153	Jackass Penguins	yes	
157	Hippos	yes	
164	Mussels	yes	
166	Platannas	yes	

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	—

AGE	
12- 13 years	
14- 15 years	
16- 17 years	X

University of Cape Town

KHANYISA MZOLO 8G

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall Impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	3	3	2	4
146	Water cycle	5	4	2	4	3	4	2
151	Penguins in peril	2	3	3	2	4	3	2
152	Penguins	4	3	2	3	3	3	4
153	Jackass penguins	3	2	3	4	2	3	4
154	Kelp gulls	4	3	3	4	3	4	5
155	Kelp gull feeding	3	2	4	3	2	2	3
157	Hippos	2	2	2	2	2	3	4
164	Mussels	3	2	2	3	4	3	4
166	Platannas	3	4	2	3	2	4	5

University of Cape Town

2. Now look back at several drawings where your overall impression was the highest (e.g. "5"), and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page ..NEW.... highly because

(i) ..THE DRAWING IS NICE AND NEAT.....

AND IT'S CLEAR AND COLOURFUL....

I rate the drawing on page ..152.. highly because

(ii) ..I LOVE THING WICH LEIVE.....

NEAR THE SEA.....

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page ...153..... lowly because

(i) ..I JUST DON'T LIKE ~~KIBECAS~~ THEM, THEY.....

ARE VERY SCARY.....

I rate the drawing on page ..157..... lowest because

(ii ..I HATE HIPPOS.....

I DON'T KNOW WHY.....

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	Yes	I JUST LIKE THEM
153	Jackass Penguins	Yes	Because they are distinctive
157	Hippos	NO	I DON'T LIKE THEM
164	Mussels	Yes	NO FOR ME BUT FOR WHITE PEOPLE TO EAT.
166	Platannas	NO	I hate them

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	X

AGE	
12- 13 years	
14- 15 years	X
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:

   5 = excellent

   4 = very good

   3 = good

   2 = fair

   1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	1	1	1	2	4	5	5
146	Water cycle	5	5	5	5	5	5	5
151	Penguins in peril	1	2	1	1	2	1	1
152	Penguins	5	3	2	3	3	3	4
153	Jackass penguins	5	2	5	5	5	5	5
154	Kelp gulls	5	5	5	5	5	5	5
155	Kelp gull feeding	5	1	2	2	3	5	5
157	Hippos	1	1	3	1	4	4	4
164	Mussels	1	1	1	1	1	1	1
166	Platannas	5	4	3	2	2	1	1

2. Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.

I rate the drawing on page ....146..... highly because

(i) Water helps us do everything we want to do and the watercycle cleans the water over and over. I like it a lot.

I rate the drawing on page ....154.. highly because

(ii) It is very satisfying and I like Kelp gulls they are beautiful birds.

3. Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.

I rate the drawing on page .....164..... lowly because

(i) I do not like it, I hate it. Its very ugly to look at its not even clear.

I rate the drawing on page .....151..... lowest because

(ii You can't see properly whether they are real penguins or what.

4. Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.

Page	Drawing	Yes or No	Reason
152	Penguins	Yes	Much brighter, Much clearer.
153	Jackass Penguins	Yes	They look alike with the real ones
157	Hippos	No.	They are very hard to tell what it is.
164	Mussels	NO.	I don't know if I've never seen it before.
166	Platannas	No.	I never saw them before

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	X

AGE	
12- 13 years	
14- 15 years	X
16- 17 years	

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	1	1	1	2	4	5	6
146	Water cycle	5	5	5	5	5	5	5
151	Penguins in peril	1	2	1	1	2	1	1
152	Penguins	5	3	2	3	3	3	4
153	Jackass penguins	6	2	5	5	5	5	5
154	Kelp gulls	5	6	5	6	6	6	6
155	Kelp gull feeding	5	1	2	2	3	5	5
157	Hippos	1	1	3	1	4	4	4
164	Mussels	1	1	1	1	1	1	1
166	Platannas	6	4	3	2	2	1	1

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	4	3	1	3	4	4	4
146	Water cycle	5	4	1	5	5	5	5
151	Penguins in peril	3	2	1	3	3	3	3
152	Penguins	2	2	1	3	2	3	2
153	Jackass penguins	3	2	1	3	3	3	3
154	Kelp gulls	4	2	1	3	3	2	3
155	Kelp gull feeding	3	2	1	4	4	3	4
157	Hippos	2	2	1	2	3	2	2
164	Mussels	3	3	1	2	3	1	2
166	Platannas	2	2	1	2	3	3	1

KHANYISA MZOLO 8G

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	3	3	2	4
146	Water cycle	5	4	2	4	3	4	2
151	Penguins in peril	2	3	3	2	4	3	2
152	Penguins	4	3	2	3	3	3	4
153	Jackass penguins	3	2	3	4	2	3	4
154	Kelp gulls	4	3	3	4	3	4	5
155	Kelp gull feeding	3	2	4	3	2	2	3
157	Hippos	2	2	2	2	2	3	4
164	Mussels	3	2	2	3	4	3	4
166	Platannas	3	4	2	3	2	4	5

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	3	3	2	2
146	Water cycle	3	3	2	3	4	2	3
151	Penguins in peril	3	4	1	2	3	4	3
152	Penguins	3	3	1	3	2	3	2
153	Jackass penguins	3	3	1	3	3	3	3
164	Kelp gulls	3	4	1	3	2	4	4
155	Kelp gull feeding	3	3	1	2	1	3	2
157	Hippos	2	3	1	2	3	4	2
164	Mussels	3	4	1	3	1	4	3
166	Platannas	2	3	1	3	2	4	2

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	3	3	3	2
146	Water cycle	4	3	1	4	4	4	4
151	Penguins in peril	2	3	1	2	3	3	2
152	Penguins	3	3	1	2	2	2	3
153	Jackass penguins	2	2	1	2	3	3	3
154	Kelp gulls	3	2	1	3	3	3	3
155	Kelp gull feeding	4	2	1	2	3	3	2
157	Hippos	2	2	1	2	2	3	2
164	Mussels	2	3	1	1	3	2	2
166	Platannas	2	2	1	1	2	3	2

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	1	1	2	2	2	3	2.
146	Water cycle	5	5	3	4	5	4	5.
151	Penguins in peril	2	4	3	2	4	3	3.
152	Penguins	3	3	1	3	3	2	3
153	Jackass penguins	4	2	1	3	3	2	3
154	Kelp gulls	4	3	1	3	4	3	4
155	Kelp gull feeding	4	2	2	4	3	2	4
157	Hippos	1	3	2	1	2	4	2.
164	Mussels	1	3	3	3	2	3	2
166	Platannas	2	2	1	2	4	3	2.

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	2	2	2	1
146	Water cycle	5	4	2	5	4	4	4
151	Penguins in peril	3	4	1	2	3	3	3
152	Penguins	4	4	1	3	3	3	3
153	Jackass penguins	3	3	1	3	3	2	3
154	Kelp gulls	2	3	1	2	2	2	2
155	Kelp gull feeding	2	3	1	2	2	2	2
157	Hippos	1	3	1	2	1	1	1
164	Mussels	2	3	2	1	1	1	1
166	Platannas	1	2	1	1	1	1	1

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2		1	4	4	3
146	Water cycle	5	4		4	4	4	4
151	Penguins in peril	4	4		2	4	4	4
152	Penguins	4	4		4	4	4	4
153	Jackass penguins	4	3		3	4	3	3
154	Kelp gulls	2	3		2	4	4	3
155	Kelp gull feeding	3	3		2	4	2	3
157	Hippos	2	3		3	4	4	3
164	Mussels	1	3		1	3	2	3
166	Platannas	4	4		4	4	3	3

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	4	2	1	5	5	4	4
146	Water cycle	5	4	4	5	5	5	4
151	Penguins in peril	1	4	1	1	2	2	3
152	Penguins	5	4	4	5	5	5	5
153	Jackass penguins	5	3	3	5	4	4	4
154	Kelp gulls	4	4	4	3	3	3	4
155	Kelp gull feeding	5	4	1	5	1	1	3
157	Hippos	4	3	4	3	4	4	4
164	Mussels	3	3	2	2	3	3	3
166	Platannas	5	5	5	5	5	5	5

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	3	2	1	4	3	3	3
146	Water cycle	5	4	4	5	4	4	4
151	Penguins in peril	2	2	1	3	5	2	3
152	Penguins	5	4	1	4	4	4	5
153	Jackass penguins	5	4	1	4	4	4	5
154	Kelp gulls	5	4	1	4	4	4	4
155	Kelp gull feeding	5	3	1	4	4	3	4
157	Hippos	3	2	1	2	4	3	3
164	Mussels	3	3	1	2	4	3	3
166	Platannas	3	4	1	3	3	4	3

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	1	3	3	2	3	2
146	Water cycle	4	4	4	4	4	4	4
151	Penguins in peril	3	3	3	2	3	3	3
152	Penguins	4	4	1	2	4	4	3
153	Jackass penguins	4	4	2	3	2	4	3
154	Kelp gulls	3	4	1	2	3	4	3
155	Kelp gull feeding	3	2	1	2	1	2	2
157	Hippos	1	1	1	2	3	3	2
164	Mussels	3	3	3	2	2	2	2
166	Platannas	2	2	1	1	3	3	2

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	3	3	1	3	4	4	3
146	Water cycle	4	3	1.	4	3	4	4
151	Penguins in peril	4	4	3	5	5	5	5
152	Penguins	5	5	2	5	3	4	5
153	Jackass penguins	5	5	2	5	3	4	5
154	Kelp gulls	5	4	2	5	4	4	5
155	Kelp gull feeding	4	3	1	4	5	4	4
157	Hippos	2	3	1	2	4	5	4
164	Mussels	3	3	2	2	3	4	4
166	Platannas	2	3	1	2	4	4	3

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	2	2	1	3	2	2	2
146	Water cycle	4	3	3	4	3	4	3
151	Penguins in peril	3	3	3	2	3	3	3
152	Penguins	3	3	1	2	1	1	2
153	Jackass penguins	2	2	1	3	1	2	2
154	Kelp gulls	3	4	1	4	3	3	4
155	Kelp gull feeding	3	3	1	3	1	2	2
157	Hippos	1	1	1	1	2	2	1
164	Mussels	1	2	2	1	1	1	1
166	Platannas	3	3	1	3	3	3	3

University of Cape Town

EVALUATION OF THE QUALITY OF THE ILLUSTRATIONS IN THE NEW NATION SCIENCE TEXTBOOK

Welcome!

Do you sometimes find that there are pictures that you can remember all your life? What made them so good? Now we are going to give you a book in which some of the pictures are good, but some of the pictures are badly drawn. We would like you to tell us which pictures you think are well drawn, and which pictures are not so well drawn. Would you like to help?

INSTRUCTIONS

1. **Choose ANY chapter in the book. Now use the table below and rate or grade each drawing by placing a number in each column according to the following plan:**

5 = excellent

4 = very good

3 = good

2 = fair

1 = very poor / unsatisfactory

Do you think you know what to do ? If not, raise your hand. Now begin. GOOD LUCK !!!!

University of Cape Town

Page	Drawing	Clearness	Size	Labels	Colour	Relevance to text	Suitable for Africa	Overall impression
E.g. 199	Egg	2	3	1	4	2	1	3
145	Days of big rain	3	3	1	3	4	4	3
146	Water cycle	4	3	1.	4	3	4	4
151	Penguins in peril	4	4	3	5	5	5	5
152	Penguins	5	5	2	5	3	4	5
153	Jackass penguins	5	5	2	5	3	34	5
154	Kelp gulls	5	4	2	5	4	4	5
155	Kelp gull feeding	4	3	1	4	5	4	4
157	Hippos	2	3	1	2	4	5	4
164	Mussels	3	3	2	2	3	4	4
166	Platannas	2	3	1	2	4	4	3

2. **Now look back at several drawings where your overall impression was the highest (e.g. "5") , and supply reason(s) for your highest rating given to these drawings. List their page number below.**

I rate the drawing on page ...146... **highly because**

(i) ...it is nice and clear, relevant and it is activity-based.

I rate the drawing on page ...154... **highly because**

(ii) ...it shows a relevant activity that the kelp gulls will be involved in.

3. **Now look back at several drawings where your overall impression was the lowest and supply reason(s) for your low rating given to these drawings. List their page number below.**

I rate the drawing on page .....145..... **lowly because**

(i) ...the colours seem to run into each other, making the picture very unclear.

I rate the drawing on page .....164..... **lowest because**

(ii ...it is not very interesting. I think most Grade 7s will have an idea of what a mussel looks like This picture tells them nothing new.

4. **Do you believe that the following four or five drawings, which you have just studied really represent what they say they are? Indicate your answer with a YES or NO. Give a reason for your answer.**

Page	Drawing	Yes or No	Reason
152	Penguins	Yes	Although not enough detail is given.
153	Jackass Penguins	NO	Doesn't show difference between other penguins
157	Hippos	NO	Shape is not clear at all.
164	Mussels	NO	Only shape is correct. Rest is very unclear
166	Platannas	NO	Unclear which is supposed to be caterpillar etc

Indicate the correct response with a cross (x)

GENDER	
Male	
Female	✓

AGE	
12- 13 years	
14- 15 years	
16- 17 years	

University of Cape Town

APPENDIX 5

NEW NATION SCIENCE (1999)

GRADE 7

TEXTBOOK

University of Cape Town

Senior Phase: Natural Sciences

NEW NATION SCIENCE GRADE 7

Frank Opie • Gus Enderstein • Olufunmilayo Amosun



NEW NATION SCIENCE
Grade 7
Learner's Book

Frank W. J. Opie
Gus Enderstein
Olufunmilayo I. Amosun

University of Cape Town

Hodder & Stoughton
A MEMBER OF THE HODDER HEADLINE GROUP
JOHANNESBURG LONDON SYDNEY AUCKLAND

Acknowledgements

The publishers would like to thank the following for permission to reproduce copyright material:

Serina Kaolin (Pty) Ltd
Photograph of Jago by Professor M Bruton

In some cases we were unable to locate the copyright holder. If brought to our attention, the publishers will be pleased to rectify any omissions in future impressions.

University of Cape Town

First published in 1999
Second impression 1999

Hodder & Stoughton *Educational*
Southern Africa
A division of Hodder Headline PLC
PO Box 3948
Randburg
2125

© F Opie, G Enderstein and O Amosun

ISBN 1 874958 70 X

Typesetting and design: Gill McDowell

Illustrations: Vusi Malindi, Sally MacLarty, Gill McDowell, Sharle Matthews, Icon Studio
Cover illustration: Sally MacLarty
Cover design: David Selfe
Printed and bound by NBD, Drukkery Street, Goodwood, Western Cape

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording or any information storage and retrieval system, without permission in writing from the publisher.

A window for opportunity ~ for teachers

Once every forty or fifty years, **a window of opportunity** opens in educational planning and allows fresh ideas to blow through and shake up the dusty cobwebs of comfortable convention and tradition. We are living in just such a time of rapid transition and growth. It is a time when old paradigms are being re-examined and tested. A time of change. Educators are now open to the bubbling ferment of yeasty ideas from wider forums involving many role players. Science needs to play a much greater and more significant role in the nation-building process in South Africa. Science can help to forge a new nation out of the many distinct cultural traditions of our land and peoples. A vibrant, new, integrated Natural Science focused on a functionary literacy is reaching far beyond the narrow preserves of conventional, content-based science. Natural Science aims to address the aspirations, needs and dreams of a new nation awakening, as if from a long sleep.

Awakened, teachers are trying to pursue excellence in a profession which is massively under-staffed and under-resourced. But there is an open road ahead inviting the learner and facilitative teacher the space and direction to grow and develop exciting and innovative learning programmes, tailored to the needs of our African communities and realities. As education material developers, our writing challenge was to make Natural Science relevant and accessible to all South Africans and to redress the academic bias of the past.

In the past, able and well-resourced teachers were able to give some learners wings. Unfortunately, this was not the experience for the majority of our people. For most learners, Science was a closed door. It seemed to be a subject protected by an esoteric language, mysterious rituals that needed to be understood with the help of an expert teacher and a no-go area for the average learner with no access to apparatus or resources. Clearly, in an increasingly scientific and technological world, this is not acceptable! The key to the closed door of exclusion needs to be found to enable the development of a nation of scientifically literate citizens.

As a result of bold planning and creative, representative curriculum development, the Natural Science learning area is emerging into the field of functional literacy as outcomes-based Science, as opposed to content-based Science. But change often comes with discomfort. Science teachers are finding themselves having to deal with learning areas hitherto not easily recognised as Science. They are being confronted with opinions, values and ethical considerations that were implicit in the older conventional science curriculum, but made seldom explicit. These new learning areas are being accorded with assessment criteria on which to judge learner performance. As a materials developing team, we too were part of that learning and assessment process. We also felt the challenges facing us as the familiar seemed less secure and the new ill-defined and inarticulate.

The challenges of outcomes-based Natural Science gave us a double task. On one hand, we needed to break a trail through the emergent broad mega themes. On the other hand, we wanted to avoid the worn paths of convenience and familiarity so that peoples' Science could become a reality in all our classrooms through our teachers.

University of Cape Town

In developing this Natural Science book, we sought to provide a flexible and user-friendly set of modules capable of being organised in many different and varied sequences and formats. Each module can be used in a week, over a combined period of 32 weeks or more. We integrated these modules, seeking to balance their physical and biotic components and to integrate them intensively within the cultural realities of our Southern African situation. Over the three years of the senior phase, all the significant inclusions of the scope statements are addressed in themes closer to the needs and interests of our communites. In the interests of accessibility and the promotion of realistic investigative skills, our apparatus is purposefully simple, homemade whenever possible. Yet this is not 'gutter Science'. Rather, we present an accessible Science that can open the investigative mind in every child, by disposing of the expensive equipment which long been denied all but the favoured few. At the same time, we have not denied the advantages of the Internet resource which we believe has much to offer all our schools, especially as library resources are scarce in our current reality and computers can bring the world closer to many more learners.

Part of our task was to help our Science colleagues in 10 000 classrooms across the country by offering them a tested and workable teaching resource. This task was not lightly assumed, but we felt confident that our collective 70 years of classroom experience and workshopping with thousands of student teachers, representing all our communities, would stand us in good stead. We owe a vote of thanks to our many students and trainee teachers for their co-operation and critical insights. You helped to make it all work!

We compiled our insights thus learnt into a separate Teacher's Book which was published alongside this learners' manual. We believe that you will find it indespensable in exploring this new learning area together. We would encourage all teachers who discover this learners' guide, to contact the publisher for a copy of the accompanying Teacher's Book. It is an investment that will not disappoint you and all questions posed in the learners' guide are answered in the Teacher's Book. The guide is also well salted with indispensable insights into the implementation of Natural Science and the new curriculum requirements as interpreted by practising teachers.

University of Cape Town

A window of opportunity ~ for you

We wanted to talk to you because this is your book. We wrote it for you! But we needed to say a few words to your teacher first. After all, if your teacher had not chosen this book, you might never have discovered it.

Welcome to our world. It's a wonderful place and, almost certainly, the only one we have right now. If you have always been a bit bored by Science or even a bit afraid of it, this book for you. This book is different. It's not about dead frogs, chemicals and glass apparatus that you never get to see or touch. This book is about people... people who use science. It's about scientists, of course, but it's also about you. Because everyone uses science - even those of us who don't think of ourselves as scientists, which includes most of us.

This is a book full of stories. It is a book that deals with real problems that real people have. It is a book about strange ideas and real investigations. The sort of investigations that you could even do at home in your own backyard perhaps. It's a Natural Science book that has less to learn off by heart and much more to do. Natural Science is about people's ideas being as important as the facts of science because Science is a people thing and people are really important.

Nelson Mandela said this for people just like you:

' Through (the window of opportunity created by) education,
the daughter of a peasant can become a doctor,
the son of a mineworker can become the head of the mine,
the child of farm workers can become the president of a great nation.
It is what we make of what we have, not what we
are given, that separates one person from another. '

Long Walk to Freedom, 1994
(The bracket is ours)

We think he might have been thinking of Natural Science education in particular, so don't miss your chance. Seize this opportunity with both hands. This is a book for your head, hands and heart. If you let it, it can improve the quality of your life now and in the future! We hope you enjoy it.

The Authors

University of Cape Town

University of Cape Town

CONTENTS

Theme: Life and Living	Page	Theme: The Planet Earth and Beyond	Page
THE FORM AND FUNCTIONS OF LIFE	1	**LIVING ON EARTH**	25
1.1 Arthropods: The successful flea	1	2.1 Bricks that build our world	25
1.2 Living with insects	7	2.2 The umbrella of life	31
1.3 The wonder of shells	13	2.3 The water world	37
1.4 Those creepy crawlers	19	2.4 The shifting crust	43
Theme: Life and Living		**Theme: Energy and Change**	
FOOD FOR LIFE	49	**THE ENERGY OF LIFE**	73
3.1 Where food comes from	49	4.1 Our star's energy	73
3.2 Danger in our food?	55	4.2 Solar energy	79
3.3 You are what you eat	61	4.3 Energy in old stones	85
3.4 The hungry people	67	4.4 Liquid energy	91
Theme: Life and Living		**Theme: Matter and Materials**	
LIVING IN THE AIR	97	**MOVING THROUGH AIR AND WATER**	121
5.1 The secrets of flight	97		
5.2 Meals on wings	103	6.1 Moving in air and water	121
5.3 Knowing where you are	109	6.2 Slipping through water and air	127
5.4 The chicken and the egg	115	6.3 Rising on wings	133
		6.4 Breaking free from the surface	139
Theme: The Planet Earth and Beyond		**Theme: Matter and Material**	
LIVING IN WATER	145	**DIPPING INTO LIQUIDS**	169
		8.1 How much do we dip?	169
7.1 The flow of life	145	8.2 Floating and sinking	175
7.2 Birds in the water	151	8.3 Floating in water	181
7.3 Under the surface	157	8.4 Floating in air	187
7.4 The living lake	163	**Answers**	193

University of Cape Town

The following themes and topics will be covered in Grades 8 and 9 textbooks:

GRADE 8	
1 **Theme: The Planet Earth and Beyond** Down a river to the sea	**Theme: Energy and Change** People, fuel and places
2 **Theme: Matter and Materials** The trees of life	**Theme: Matter and Materials** Building with wood
3 **Theme: Life and Living** Healthy at home	**Theme: Life and Living** Safe at home
4 **Theme: Matter and Materials** A home in the veld	**Theme: The Planet Earth and Beyond** Our home in space
GRADE 9	
1 **Theme: Life and Living** Living within the life budget	**Theme: Energy and Change** Conservation of energy
2 **Theme: The Planet Earth and Beyond** Threats to life	**Theme: Matter and Materials** Dealing with waste
3 **Theme: Energy and Change** Getting older	**Theme: The Planet earth and Beyond** The passage of time
4 **Theme: Energy and Change** Changes old and new	**Theme: Matter and Materials** Getting around

ASSESSMENT CRITERIA CHART

The following chart shows you assessment criteria relevant to each section. For a more comprehensive personal assessment chart please refer to the back of the Teacher's Book.

SPECIFIC LEARNING OUTCOMES	ASSESSMENT CRITERIA	MODULES IN NEW NATION SCIENCE GRADE 7
NS-SO1 **Investigations**	• Identify investigative questions • Formulate hypothesis • Predict results • Design action plans • Gather data • Analyse and evaluate (test hypothesis) • Communicate conclusions	• 1.1, 2, 3, 4 • 2.1, 2, 3, 4 • 3.1, 2 • 4.1, 2, 3, 4 • 5.1, 2, 3, 4 • 6.1, 2, 3, 4 7.1, 3, 4 • 8.1, 2, 3,4
NS-SO2 **Concepts**	• Understand concepts • Apply understood concepts	• 1.1, 2 • 2.1, 2, 3, 4 3.2 4.1, 2, 3, 4 5.3 6.1, 2, 3, 4

University of Cape Town

NS-SO3 **Problem solving**	• Identify the problem • Identify viewpoints • Gather information • Identify scientific information • Identify scientific principles/select scientific skills • Re-evaluate problem • Explore viable options • Identify plan of action	• 1.1, 2 • 3.1, 2, 3 • 4.1, 2 • 5.2, 3, 4 • 6.1, 2, 3, 4 7.1 • 6.1, 2, 3
NS-SO4 **Resource management**	• Identify resources • Gather information • Identify scientific information • Investigate consequences of contested management practises • Predict consequences of alternative use of resources • Communicate conclusions	• 1.1, 3 • 3.1 • 6.4 • 7.1, 2, 3, 4
NS-SO5 **Decision making**	• Identify issues • Gather information • Sort information • Select relevant information by criteria management practises • Consider alternatives • Communicate a reasoned decision	• 3.4 • 6.1, 2 • 7.2, 3
NS-SO6 **Science and culture**	• Gather information on use of science in other cultures • Consider alternative explanations of phenomena, e.g. religious, scientific, artistic	• 1.3 3.2 • 6.2 7.2, 3
NS-SO7 **A way of knowing**	• Gather information of the historical development of a scientific theory • Consider scientific theory in the context of social beliefs • Recognise that scientific theories are subject to change	• 2.4
NS-SO8 **Values related**	• Identify viewpoints and bias • Identify the origins of bias • Identify scientific information related to contested issue • Communicate conclusions recognizing ethical and scientific considerations	• 3.4 • 6.4
NS-SO9 **Quality of life**	• Identify how science is of practical use in society • Demonstrate an understanding of how science and technology complement each other in society • Demonstrate how science improves life of people through better quality of life and employment	• 2.2 6.4

University of Cape Town

University of Cape Town

THE FORMS AND FUNCTIONS OF LIFE

1.1 ARTHROPODS: THE SUCCESSFUL FLEA

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Do a survey to collect information about fleas.
2. Analyse your information to see what it means.
3. Evaluate an outbreak of plague using the knowledge you gained about fleas.
4. Make decisions about solving the problem of the plague based on this scientific knowledge.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Learning to use process skills in an explorative investigation.
NS-SO3 Learning to solve problems and make decisions.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify the stages of a flea life cycle.
2. Conduct an accurate survey of the fleas on a dog.
3. Graph and analyse the flea data collected by the class.
4. Evaluate an outbreak of the spread of plague.
5. Gain experience in making a good decision based on scientific information.

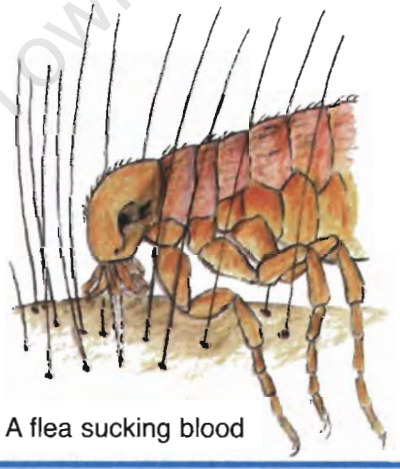
The Deadly Plague Flea

Fleas seem harmless, but this is not always the case. One of the most deadly diseases known to human beings - the Black Death or Bubonic Plague - was spread by rat fleas to people. Between the 14th and 16th centuries in Europe, 135 million people died of the Black Death after being bitten by infected fleas! This disease is still a threat today in Africa, but it can be cured.

Rats are attracted to areas where they can find food easily, like rubbish dumps. Communities with lots of rats have a greater chance of an outbreak of diseases like the plague. Rats often carry diseases and some may carry bacteria that causes the plague. The fleas from these infected rats can jump onto people. A bite from an infected flea can be dangerous.

The plague bacteria block up the flea's blood-sucking mouthparts. When the hungry flea tries to bite you, it squirts the bacteria into you so that it can feed on your blood more easily. If the flea that bites you carries the plague, then the bite area turns black and your blood vessels block up. Your arms, legs and neck become swollen and sore from painful abscesses. You get a high fever, vomiting and pain all over as the poison from the bacteria spreads through your body...

Fortunately, in modern times we have antibiotics to help us. In southern Africa, some wild rodents carry plague bacteria. These wild plague-carrying rats from the veld can infect the domestic rats in our communities. And then their fleas can spread this disease to us.



A flea sucking blood

A game or a warning?

Young children today still play this game and sing this song about the Black Death.

Ring around the rosies
Praying with rosary beads for God's help against the Black Death.

A pocket full of posies
Flowers carried to hide the rotting smell of bursting abscesses.

Ashes, ashes!
Burning the dead bodies.

We all fall down
Untreated, the plague can kill 75% of those who contract it. In Europe in the 14th and 16th centuries, one in every four people died from this plague.

University of Cape Town

EXPLORING SCIENCE REPORTS OF PLAGUE

BUBONIC PLAGUE OUTBREAK IN ZAMBIA

Early in 1997, 267 Zambians contracted the Black Death. The plague killed 30 people in the Namwala area before it was checked. The disease broke out in four places at the same time. At first the clinic staff thought it was a sexually transmitted disease and did not treat it as plague. When the correct diagnosis was made and the right medicine was given, patients stopped dying.

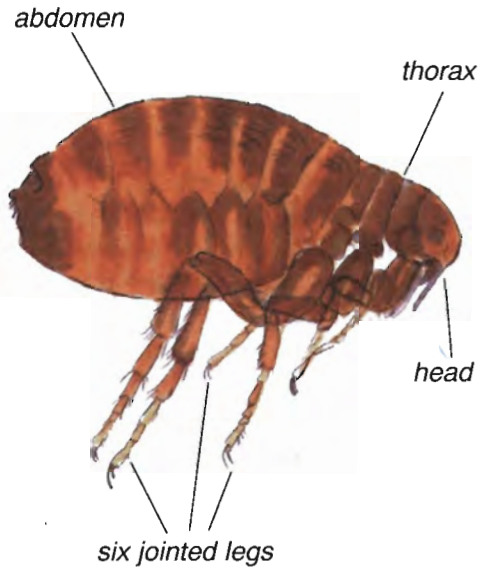
- Saturday Star
(condensed)

Read this report in your groups. Use your understanding of fleas and the plague to decide what should be done to prevent this happening again. Share your solution with the rest of the class.

Questions for your group to answer:

- Get an atlas and find Namwala in Zambia. Is it near the capital city and an airport?
- Why did the plague start in Zambia ?
- Why did so many people contract the plague so quickly?
- How did the plague spread so fast to four different areas?
- What do you think is the best way to stop the plague locally? How would you do this?
- How would you stop the plague spreading further to other places, like your home town?

It's very hard to catch an animal that is tiny, jumps far and is tough. The flea lives in the hairy coats of animals or the feathers of birds. It hides its eggs, so it can spread quickly. It's hard to catch fleas, but easier to catch the rats that carry them. Cats can help keep down the rat population.



It's a dog's life!

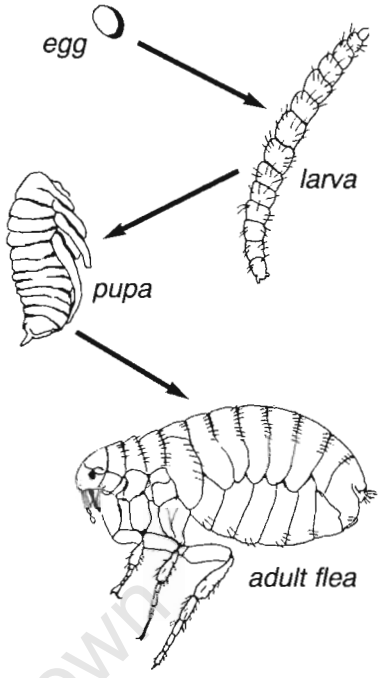
If you have a dog or a cat at home, they probably have fleas. The fleas on domestic animals are not plague fleas, but they can still bite. Fleas are parasitic insects. In their adult stage, they feed on the blood of our pets.

Fleas have *six legs, a head, thorax, abdomen,* but *no wings.* Their bodies are flat to make it easy for them to slip between the hairs on an animal's skin. Look at the picture on the left. How is this flea adapted for living on a dog or cat? Once the female flea has fed on blood, it can lay one egg per hour. That means it can lay about 600 eggs in its lifetime. That is a lot of fleas!

University of Cape Town

The stages of flea development

After a flea lays an egg, the egg can roll into any tiny crack in the floor, in a carpet or in the sand. Here it hatches into a larva. The larva feeds on dried flea faeces, dried blood and skin scales. As it grows, the larva moults three times and then spins a silken cocoon around itself. In the cocoon it turns into a pupa and then hatches out as an adult flea. If a warm, furry animal comes near the pupae, the hungry fleas hatch out of their cocoons to feed.



Life cycle of the flea

Fleas are good jumpers. They can leap 150 times their own length and jump about 600 times an hour! This helps them to jump onto passing animals. Sometimes if you go into an empty house, the hungry fleas will jump onto you. Some people let their dog run into the house first to collect the fleas. Then they chase the dog outside so that the fleas can go outside as well.

EXPLORING SCIENCE STUDYING FLEAS

Fleas are found where dogs live and sleep in our homes.
You can survey the fleas in these places.
Share your flea surveys with your class.

1. Place a shallow pan of water, mixed with a few drops of dishwashing soap under a desk light. The adult fleas will be attracted to the warmth and light. They will jump into the water and drown.

2. Another method is to wear a pair of white socks and then walk around in the dog's bed. Look carefully - you may even find some larvae and pupae at the edge of the dog's bed. The fleas will jump on your feet. You can collect the fleas and put them in a small plastic jar of soapy water. Record your catches after two minutes. Five fleas in one minute is a lot!


You can trap fleas by placing a lamp and a dish of water near a dog's bed

3. You can often see fleas walking on white or light coloured dogs.
   Where do most fleas live on a dog's body?
   Why do you think fleas prefer these places?
   If the dog will let you, try to collect as many fleas as you can in five minutes.

University of Cape Town

WHAT I HAVE LEARNT about fleas

Write a letter to a friend. In the letter, tell them what you have learned about fleas. Remember to include how a flea develops through four stages. Tell your friend what fleas look like, why they are insects and why they can be dangerous.



Arthropods - The biggest group of all

All animals are divided into two main groups - those with backbones (vertebrates) and those without backbones (invertebrates). Fleas, and all insects, belong to a group of animals called **arthropods**. Arthropods are invertebrates.

Almost all animals are arthropods. They are the most varied animal group on Earth. Most arthropods have *hard, segmented bodies with jointed legs* which are highly specialised for different types of movement (walking, flying, swimming, or eating). They usually breathe by means of *gills* or *air tubes (tracheae)*. The word 'Arthropod' means **jointed feet**.

So far, scientists have discovered over 900 000 species of arthropods sharing this planet with us. Some are very useful but others are real pests and some of them can even be dangerous!

Look at the list of animals on the right.

House fly

Mosquito

Cockroach

Butterfly

Bee

Beetle

Flea

Ant

Termite

Spider

Scorpion

Tick

Crab

Crayfish

Millipede

Centipede

Locust

















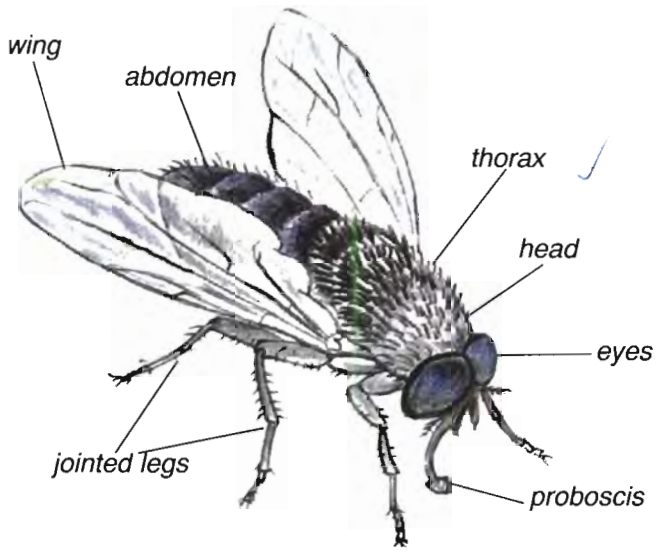






University of Cape Town

EXPLORING SCIENCE SHAPED FOR LIVING



Body parts of a fly

Every arthropod tells a story of where and how it lives by the shape and build of its body parts.

Find any insect, alive or dead, and bring it to school in a plastic jar.
Look carefully at its body shape, and draw it.
Make your own notes about the length and shape of its legs.
Look to see if it has a neck or waist.
How do you think it feeds?
Share your findings with someone else in the class.

Arthropods are everywhere because...

- many are armoured - they have a tough outer skin (*exoskeleton*).
- they are strong - their many legs are hollow muscular levers.
- many have wings to fly away from danger or towards food.
- most lead air directly to their cells for quick energy release.
- they eat almost any food - their mouth parts are very varied.
- the young have a different diet from the adults - so there is no competition between adults and larvae for the same food.
- they have good sensors (eyes, feelers, ears) for food and danger.
- they lay many eggs - they reproduce their young in great numbers.

University of Cape Town

WHAT I HAVE LEARNT about arthropods

Match the statements on the left with the answers in the right hand column.

1. 'Arthropod' means ...
2. They all have ... (5 answers)
3. They increase their numbers rapidly because they ...
4. The biggest group are the ...
5. Give the name of any arthropod for which all the answers in the right hand column are true.

a. wings
b. insects
c. segmented bodies
d. lay many eggs
e. an exoskeleton
f. hollow muscular legs
g. specialised limbs
h. having jointed feet

WHAT I HAVE LEARNT about disease control

Read the statements below. Are they true, false or half-true?

1. Insects can carry diseases to humans.
2. The Black Death started in fleas.
3. Clean houses have fewer fleas.
4. Fleas prefer living on dogs to humans.
5. We don't need insects at all.
6. Fleas are arthropods because they have jointed feet.

Remember these new ideas

We have learnt these new words. Select their meaning from the list on the right and then add them to your Natural Science dictionary.

abdomen	Medicines that kill bacteria
antibiotics	The stage after the larva changes to an adult insect
arthropod	The caterpillar stage of an insect
bacteria	Tubes that take air to body cells
exoskeleton	Segments forming the rear end of an arthropod
insect	Minute organisms that may cause diseases
larva	A hard, segmented body with jointed legs and feet
pupa	A hard, outer skeleton covering the body
thorax	Segments where the legs join the body
trachea	An insect with jointed legs

University of Cape Town

WHAT I HAVE LEARNT about the tools of science

A scientist...

- Decides what question to answer before looking for data. (e.g. Where do you find fleas? Only then can you begin to count them.)
- Looks carefully for and counts the number of sightings in a set time. Science is measurement. (e.g. How many fleas did you find per minute?)
- Presents data as a graph, if possible. (e.g. What information would you plot against which two axes?)
- Makes a decision, after first considering all the alternative choices. (e.g. Plague treatment - the treatment for sexually transmitted diseases was not a good decision because more people died! Somebody *guessed* the solution, instead of studying the problem closely.)
- Chooses the best solution to solve a problem.

1.2 LIVING WITH INSECTS

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Design solutions of how to deal with a locust swarm based on information you have collected.
2. Investigate the diet and breeding of the locust so that you understand the control problems.
3. Investigate and report on insect visitors to a plant.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Learning to conduct investigations.
NS-SO2 Learning to identify and select relevant scientific information.
NS-SO3 Learning to solve problems in innovative ways.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify the problems of trying to control a locust swarm.
2. Investigate locust feeding and breeding and use the data to assist in the design of the best methods to solve the problem.
3. Propose the best solutions to the problem through discussion and research resources.
4. Collect data on insect visitors to plants, present it graphically and interpret it.

The Hungry Invaders



'There in the direction of the village was a cloud in the sky. It moved towards us growing larger and denser and browner, and as it approached I heard it... Then the locusts were above and around us and the roar changed to a rasping and clicking and scratching and pattering. We put up our hands to shield our faces, for they flew against our cheeks and into our eyes; they tangled in our hair and clothes and they crept into our pockets and down our necks. Every door and window of the house was shut and still the locusts penetrated. We found them in our beds and in our food and drowned in the flower bowls and in our tea.

As I lifted a mug of milk, a struggling locust rasped its armoured legs against my lips. I shrieked. Outside the world moved and it was a grey world. I remember shielding my eyes and staring upwards, and my feeling of astonishment that the sun I saw was no more than freckles of brightness in the whirring shadow. At night the locusts settled and we went into the veld to see them. They were now far more horrible than by day, for they covered every bush and our landscape was enveloped in a cloak of shuddering, sighing life.

During the years that followed, we saw the locusts again and again, always travelling in the same direction for days on end and sometimes, it was said, covering 140 kilometres in a single day. Sometimes they flew, sometimes they were in the hopping stage, voetgangers (travellers afoot)... the hoppers never held the same terror for me as for the farmers... because they never clicked against my teeth or twined themselves in my hair.'

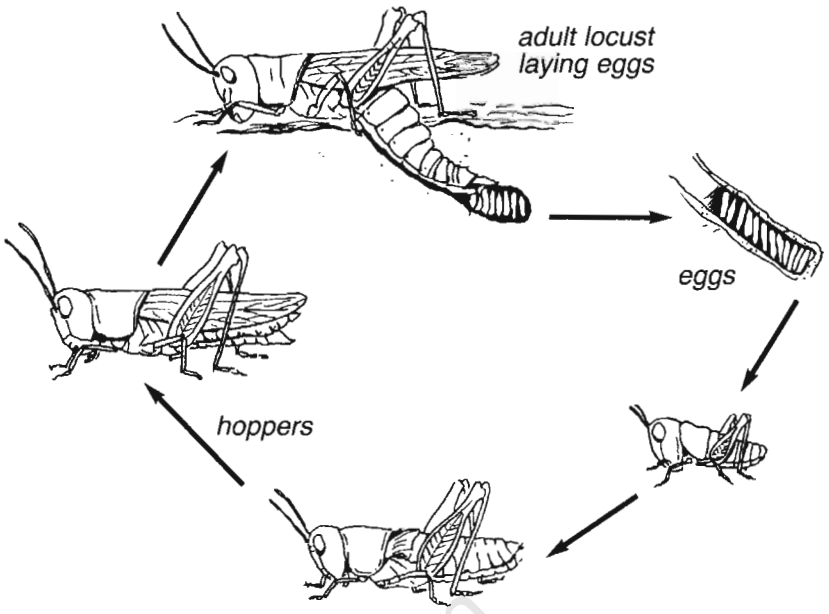
- A child's eyewitness account of swarming locust in the Karoo.

(Eve Palmer, ***The Plains of Camdeboo,*** Fontana, pp 213 - 214).



'And the Lord brought the locusts on the east wind to Egypt... and the locusts covered everything. The ground was covered, the sky was dark with locusts. They ate every green thing and the fruit of all the trees in Egypt. And Pharaoh asked Moses to beg God to take this death away from his land.'

You can read about locusts in the Bible in **Exodus** 10:12-20 and in **Joel** 2:1-10.



Life cycle of the locust

EXPLORING SCIENCE STOPPING A LOCUST PLAGUE

Imagine that a swarm of locust invaded your home town.
Find out about locusts by discussing the following questions in your groups:

- What is a locust?
- Where do locusts breed?
- Why do so many locusts appear in some years but not in other years?
- How can locusts be controlled safely?
- Try to think of three different methods of controlling locusts.

In your groups, discuss the best way to stop a hungry, mobile swarm of hoppers or flying locusts from eating everything in sight. In the past, people used chemical poisons. These poisons killed the locusts, but they also killed thousands of useful animals and birds that fed on the poisoned locusts. If these useful animals are killed, they will not be able to help get rid of the locusts. The locust problem will get worse! What can we do to get rid of the pests without killing too many useful species? Share your ideas with other groups in the class.

Locust attack

A hundred years ago, a swarm of red locust attacked the vineyards of Constantia in the Western Cape. The farmers and their helpers had to kill thousands of the locusts by snapping them in half by hand, one by one. They also used wet towels to beat the locusts to death. In this way they were able to save some of the grape crops.



University of Cape Town

EXPLORING SCIENCE A MOVING, EATING, EGG-LAYING MACHINE

If you can, catch a few live locusts and bring them to class.
Keep them a container that you can see into, like a bird cage covered with a clear plastic bag.
How do you know that the locust is an insect?

Design your own experiment to find out what locusts eat.

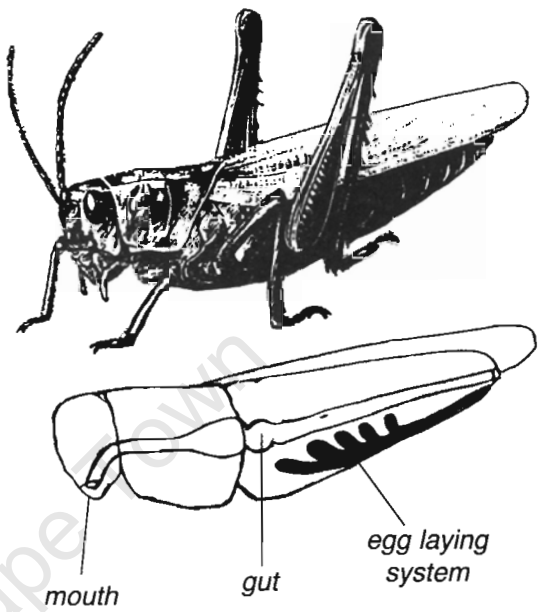
- How could this information help you to control a locust plague?

Feed your locusts well and keep them in a warm, moist place.

- How does warmth and food affect locust behaviour?
- How does this help solve your control problem?

Locusts can travel far and live in very dry places.

- How do they do this?
- Name the parts of the locust's body you can see in this picture.
- How does each part you can see help your locust survive?
- What does the simplified inside view tell you about your locust?



Inside parts of a locust

University of Cape Town

WHAT I HAVE LEARNT about locusts

Record what you have learnt so far about locusts by completing these statements:

1. Locusts are problem insects because...
2. Locust survive in great numbers because...
3. Locusts can be controlled because...



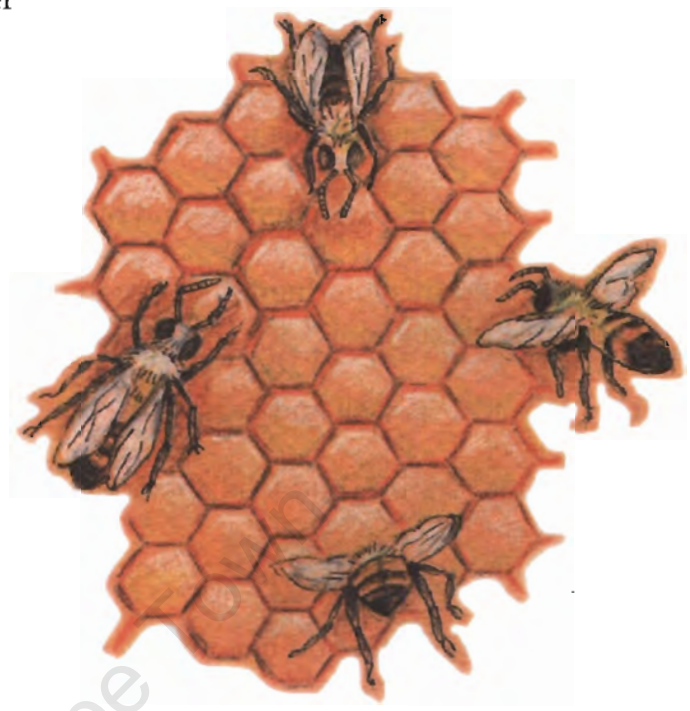
Eating like a locust!

Look at this illustration of the mouth of a locust.
How do you think each part is used by the locust to eat its food?

Put your fingers on either side of your mouth. Try to eat like this!

The angry insects work together

Insects are usually small and don't need much food. Bees are social insects and work together as a community. Together, they can get a lot of work (and eating) done!



If you disturb bees or wasps while they are on the job, they can sting you painfully. Some people are allergic to bee stings. If they get stung by a swarm of bees, they could die unless they get medical help fast.

In spite of the danger, people have been keeping bees for centuries. They are useful insects and are very valuable to us. They pollinate flowers. Seeds and fruits grow in and from these flowers. Our fruit farmers know that bees help to increase their fruit harvests by up to 20% each year. If there are fewer bees, there will be less fruit and less food.

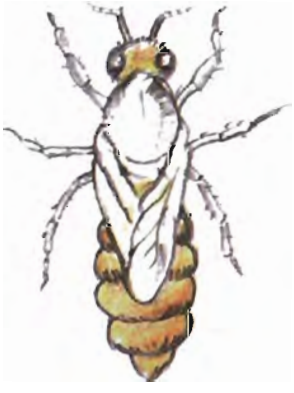
Bees also collect nectar from flowers. They use this nectar to make the rich, sugary food we know as honey.

University of Cape Town

Can you spot the queen bee ?







Find out:

- How is the queen bee different from the worker bees?
- Which is the worker bee in the picture? What is the role of worker bees?
- Why is there lots of honey in a hive in summer but very little in winter?
- Why do we call bees 'social insects'?
- Which is the drone bee? What does it do?

EXPLORING SCIENCE HARMFUL INSECTS

In your groups, decide which of the insects listed below are responsible for the following problems:





- They attack our bodies
- They attack our food
- They attack our animals or plants
- They attack our clothing
- They attack our houses

mosquitoes	house flies	tsetse fly
ants	termites	cockroaches
clothes moths	butterflies	aphids
horse fly	blue fly	borers
weevils	furniture beetles	locusts



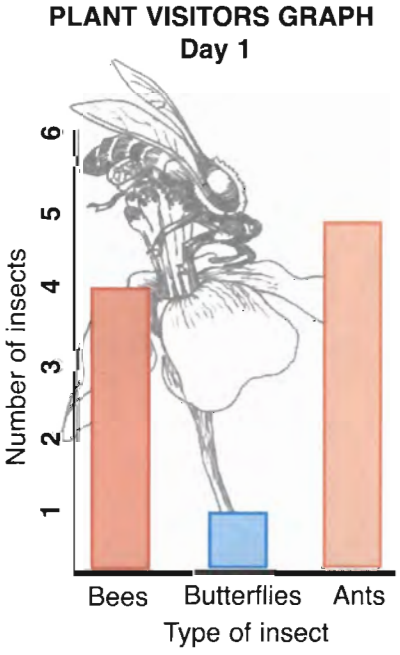
In your groups:
Choose one of these insects listed above.
Find out all you can about this insect.
Make a poster of the insect and show the damage it does, and how we can control it.
Share this information with the class.



University of Cape Town

A flower visitor's book (Do this activity yourself)

- Find a nice quiet safe place to sit in a garden near a plant that has brightly coloured flowers.
- Watch the plant for 15 minutes every afternoon, for five days.
- Keep a visitor's book of all the insects you found living on or visiting the plant during this time.
- Draw a table of the different types of insects and how many there were each day.
- Plot some bar graphs like the one shown. (List types of insects, numbers of insects for different days).
- Try to explain what the graphs mean.
- Do some flowers get more visitors than others? Why?
- Which type of insects visit the plant most often? Why?



Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

nectar	A sugar solution produced by some flowers
allergy	The process by which pollen reaches the stigma of a flower leading to fertilisation and seed formation
pollinate	A body reaction to a poisonous substance

WHAT I HAVE LEARNT about the tools of science

A scientist...

- Looks for solutions to problems that can be solved by measurement.
- Asks questions and reads to see if any answers are already known.
- Suggests alternative solutions to a problem.
- Conducts investigations (experiments) to find out more information.
- Collects and records data to help with the investigation.
- Looks for the best solution and makes recommendations for the use of the best solution to solve a problem.

University of Cape Town

1.3 THE WONDER OF SHELLS

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Discuss the cultural and scientific aspects of harvesting perlemoen as food.
2. Identify the special features of molluscs that help them to survive.
3. Understand the importance of calcium carbonate in our modern society.

THE MAIN SPECIFIC OUTCOMES:

NS-SO6 Understanding the relationship between science and culture.
NS-SO1 Investigating the design of mollusc shells for life in water and on land.
NS-SO4 Understanding the scientific management and development of a resource.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Contrast the differences of opinion regarding perlemoen harvesting and conservation from a scientific and cultural perspective.
2. Investigate life in water by accessing information, and debating the design of shells.
3. Describe the carbon and carbonate cycle acknowledging their importance for society at local and global levels.

Food and Money in Shells - Perlemoen Poaching

A small boat chugs into the hidden cove at night. In it is a compressor, air hoses, wet suits and lead belts. Three men jump out dragging heavy bulging sacks to a rusty car parked in the shade of the bushes nearby. Another load of perlemoen is on its way to the Asian markets...

Below are quotes from people involved in the perlemoen industry. Discuss their views in your groups. What do you think the problems are? What do you think the government should do? How can our perlemoen industry can be saved?

- *'It's not easy! There are two types of poachers: those who poach to feed their families and those who are members of criminal gangs.'*
- *'Everyone agrees that they don't want to see the perlemoen disappear!'*
- *'The police don't dare to come here when we're busy. They know we'll fight! It'll have to be a major operation, and we'll always get a warning of that.'*
- *'The national quota is 550 tons of perlemoen a year, but we take out 500 tons a year here alone.'*
- *'People don't respect the pearlies any more. They haul out everything. I am forced to poach because I don't have work and I have a family to feed. I'm sad to poach... but I have to!'*
- *'We collect bags full each night.'*
- *'It's only fair for us to take more. Under the last government we had no quota at all.'*
- *'I smuggle them out... to Hong Kong. They pay me R1 200 per kilogram. Here I only get R140 per kilogram.'*
- *'If they catch you, it can cost you R50 000 or six years or both. But it's the criminals that they are after, not people like us.'*
- *'There are too few inspectors and they live in the community with us, so what can they do? Their families are here too.'*
- *'Maybe the answer is to create more marine reserves or restock the shore with immature perlemoen like the Japanese do.'*

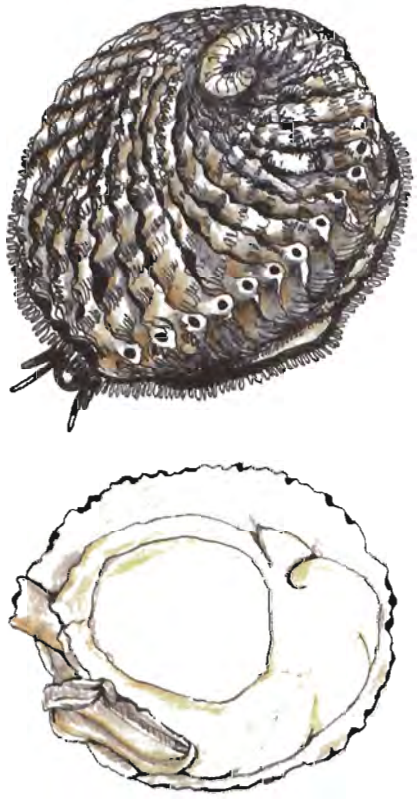
Perlemoen regulations

The perlemoen is a sea snail which lives on seaweed, especially kelp. It grows very slowly and can take 13 years to grow to full size! It only starts breeding when it is eight years old. During this time the perlemoen can lay up to ten million eggs.

To protect the perlemoen so that it does not die out, the harvesting of the perlemoen is controlled by legislation. A permit allows anyone to collect four adult (114mm diameter) perlemoen a day in the summer season. Commercial divers are given an annual quota limit based on the same size and seasonal restrictions.



University of Cape Town



A perlemoen with its shell removed

Collect a sea shell from your teacher to study or study these pictures of a perlemoen. The shell is formed by a soft bodied snail-like animal called a ***mollusc***. Try to find out more about molluscs from books. Share information about your specimens. Investigate your animal and answer the questions below in pairs.

- Why does a mollusc need a shell?
- How does the shell help molluscs to survive?
- How does your mollusc breathe under water?
- How does oxygen get into the animal?
- What does your mollusc feed on?
- Are shell colours important to a mollusc?
- ***Shell shapes are designs for living.*** Do you agree with this statement? Why?

University of Cape Town

Living in a shell

Molluscs are animals that usually live in water that is full of minerals. They eat plants that are also full of minerals that they get from sea water. The mollusc gets rid of the calcium carbonate it gets from the sea water by secreting this mineral from its mantle through the mantle lip. The secreted mineral hardens and forms the shell around the mollusc's soft body.

When there is plenty to eat, molluscs grow fast and the shell enlarges around their body. When they stop eating, a thick ridge or growth ring forms next to the shell opening. Bumps and spines form on the shell because there are frills on the edge of the fleshy mantle lip. The mantle lip is the opening of the shell. The shape of a mantle determines the shape of the shell. The shape of the shell tells us where the animal can live. For example, perlemoen live exposed on rocks and white mussels live buried in the sands.



What is the advantage of the long spine and bumps on this shell?

Molluscs as cultural symbols

Since ancient times, people have attached value to shells. Rounded **cowries** were used as money in tropical Pacific Ocean islands. People believed that the cowrie shells warded off evil. They were also used as symbols of life and fertility. People believed that they could use cowries for money in the after life. Rich men were buried with their mouths full of money cowries so that they could buy food in the next world!



Tropical money cowries

Cowrie shells were worn as pendants, necklaces, girdles and belts, shirts or skirts. People believed that the wearer of the shells could avoid sterility, increase fertility, and ease delivery in childbirth. Cowries were believed to give the wearer knowledge of future hunts and wars.

In Africa, we have the wonderful Giant Snail. The shells from these snails have been used as milk bottles for babies, tea cups, pottery polishers, shell beads and clay scrapers by our people at different times. In Africa, the snail coming out of its shell is seen as a symbol of the resurrection of the dead by some people.



Shell of a Giant African Land Snail

University of Cape Town

EXPLORING SCIENCE MOLLUSCS: SURVIVORS ON LAND

Find a garden snail and bring it to class. These snails have adapted to life on land. In your groups, answer the following questions by studying your snails:



- How do land snails stay wet in hot weather?
- How do snails travel over dry ground without drying out and without legs?
- Where do land snails get the calcium carbonate to make their shells from?
- How do land snails breathe?
- How do their shell patterns and colours help them?
- Why do land snails have no spines or bumps on their shells like sea snails?

WHAT I HAVE LEARNT about molluscs

1. How do you know when an animal is a mollusc?
2. Molluscs protect themselves by...
3. The difference between land and sea snails is....
4. Explain the different problems to be solved in breathing under water and on land.
5. What reasons can you give to protect and conserve our mollusc resources, like the perlemoen?

From Shells to Limestone...

Carbon dioxide (CO_2) is a gas which dissolves in water.
In sea water, where calcium is found in soluble form, carbon dioxide forms ***calcium bicarbonate*** which is used as ***calcium carbonate*** ($CaCO_3$) in mollusc shells. When these molluscs die, their shells lie on the sea floor.

Some shells wash up onto the beaches. Crushed shell grit is always found just below the surface of sandy beaches. The wind blows fine sand and calcium carbonate inland. This forms beaches and sand dunes. When plants grow on these dunes, the calcium carbonate is dissolved by acid released by rotting plants into the soil. It forms a natural cement (*calcrete*).

Shells in the sea can also break down and dissolve and then form limestones, chalks and even marbles. So the shells become stone which can be cut up and used for building blocks. This stone can also be quarried and crushed to make cement.

... and from Limestone to Cement

When calcium carbonate (which makes shells) is broken up and heated, it becomes ***lime*** - Calcium oxide (CaO). Lime is mixed with clay to form cement powder. When water is added to cement powder, heat is given off and carbon dioxide is absorbed to form calcium carbonate again. Like shells, this hardens as it sets, into any shape we choose.

This cement is very brittle, so we add sand, stone or even iron rods to it to make it stronger.
How you mix cement depends on what you want to build - a house, a bridge or a swimming pool.

Making cement from shells

Before the discovery of Portland cement in 1824, cement was made from shells that were collected and placed in simple open pit kilns.

These lime kilns were wood fired and stoked up until the CO_2 (carbon dioxide) was burnt off from the $CaCO_3$ (calcium carbonate), forming CaO (lime). When this lime was added to water, it formed cement which was used to build houses.



University of Cape Town

EXPLORING SCIENCE THE AMAZING CEMENT OF LIFE

1. **A test for calcium carbonate.**
   Take an empty snail shell or sea shell and crush it with hammer.
   Add a drop of dilute hydrochloric acid to the crushed shell in a test tube.
   - What happens?

   The gas which forms is dense and remains in the test tube. Lower a burning match into the test tube.
   - What happens?

   Try dripping some diluted hydrochloric acid on any cement surface.
   - Explain what happens.

2. **When cement sets...**
   Take some Portland cement powder. Add enough water to stir it into a thick paste. Push a thermometer into the mixture. Record the temperature changes at regular intervals. Draw a graph of the temperature changes. Where does the heat come from?

3. **Reinforcing cement**
   Make four small cardboard moulds (about 10 x 10 x 2 cm).
   Prepare four mixtures of cement, sand and stone chips as follows:
   - 1 part cement and 6 parts sand;
   - 1 part cement and 4 parts sand;
   - 1 part cement, 3 parts sand and 1 part stone chips;
   - 1 part cement and 1 part sand.

   Make sure that all the mixtures are of the same size. Add water to set the mixture.
   Allow three days for the drying and curing of your tiles.
   Design your own experiments to test the strength and waterproof qualities of each tile.

WHAT I HAVE LEARNT about shells and cement

Are the statements below true, half-true or false?

1. All cement comes from calcium carbonate that was once formed in the body of a living animal.
2. All calcium carbonate resources are found in the sea.
3. When cement is made, carbon dioxide is given off.
4. When we make cement powder we are using resources that took a very long time to form.

How is this statement true?

5. The home of the sea snail is also our home.

Challenge question

6. The making of cement powder is the world's third main cause of carbon dioxide (CO_2) pollution in the atmosphere. How does the addition of more CO_2 to the atmosphere affect people? Why is this a 'modern' problem?

University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list on the right and then add them to your Natural Science dictionary.

calcium carbonate	A mixture of lime and clay
cement	A permitted harvesting of a resource
lime	A soft bodied animal, often with a shell
mantle	The thin skin layer lining the gill or lung cavity
mantle lip	The chemical compound in shells
mollusc	Calcium oxide
quota	The part of the mantle that secretes the shell

WHAT I HAVE LEARNT about science and culture

- A scientist may sometimes interpret the meaning of things in one way and communities in another. For example, scientists say it is bad to over-harvest the perlemoen for food, but for communities it is worse to starve to death.
- Communities may value resources for very unscientific, but valid, reasons. For example, the cowrie shell is used and valued in some communities, where it is used as currency. In Western cultures people have valued gold and oil and used them as money currency.

University of Cape Town

1.4 THOSE CREEPY CRAWLERS

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Collect information about web spinning spiders by observing a web for several days.
2. Find the answers to your own question about spiders using a variety of information sources.
3. Design your own experiment to answer questions about hunting spiders.
4. Run your own investigation into the habits of hunting spiders based on your own design.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Learning to use process skills in an explorative investigation.
LLC-SO4 Accessing information from a variety of sources.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Collect data on factors influencing web distribution through observation.
2. Access and present spider information gathered from many different sources.
3. Design their own investigation to check a given statement about hunting spiders.

Ambushed in Sabi!



The open land rover rolled slowly along the winding earth road between the trees in the Sabi Game Reserve in Mpumalanga. We were looking for a leopard and our eyes were searching the surrounding bush... so we weren't expecting what happened next. Rounding a bend, we drove slowly through a great spider's web which was stretched completely across the road. I could scarcely believe what was happening!

In the centre of the web, which was level with my head, sat a giant spider, big enough to cover the palm of my hand. It was the awesome Golden Lowveld spider. A strong yellow and black design covered her huge sausage-shaped abdomen, surrounded by evil-looking, thin black legs. The web was a massive affair, strong enough to catch insects and even some small birds. Some locusts had already been caught in it. I stopped looking and ducked down well as the centre of the web swept over my head. We were through the ambush! Looking back, I imagined the horror of the web plastering the giant spider to my face, as I struggled to free myself.

How do you feel when reading this story?

- What words caused horror?
  Read the story again and change the horror words into ordinary words which describe the situation, but *without the fear*.
- Do you think the spider was doing a good job? How?
- If there were no spiders in the world, what would we have many more of?

If you wish to live and thrive,
Let the spider walk alive.

What is the cultural wisdom in this old English rhyme? In Africa, spiders are sometimes associated with knowledge and wisdom. Do you know of any 'wise' spider stories like this?

Are you an arachnophobe?

- I can't sleep in a room with a live spider
- I would not let a spider walk over my hand
- I don't like even looking at pictures of spiders
- I'm very scared of all spiders

If you answered '**yes**' to all of the above statements, then you are an arachnophobe!

Arachnophobia is the fear of spiders. But this fear may be unreasonable because most spiders do more good than harm.



The Golden Orb spider

EXPLORING SCIENCE LOOKING AT SPIDERS AND WEBS

You will need:
a note pad, a pencil, a ruler and, if possible, a magnifier.
Go and look all over for a spider's web.
There are two types of spiders: those that spin food-catching webs and those that don't.
Look for a fresh web. When you find a web, look carefully for the spider.
Is it on the web or hiding nearby? Touch the web gently and see what happens.



Make a careful drawing of your web every day. Early morning is often a good time to observe your web before the spider's night work is damaged.

Make your own measurements to gather information about the position, shape and size of the web.

- How is it adapted to survive wind and rain?
- Is it a successful web for catching insects or not?

Revisit your web for four days in a row.

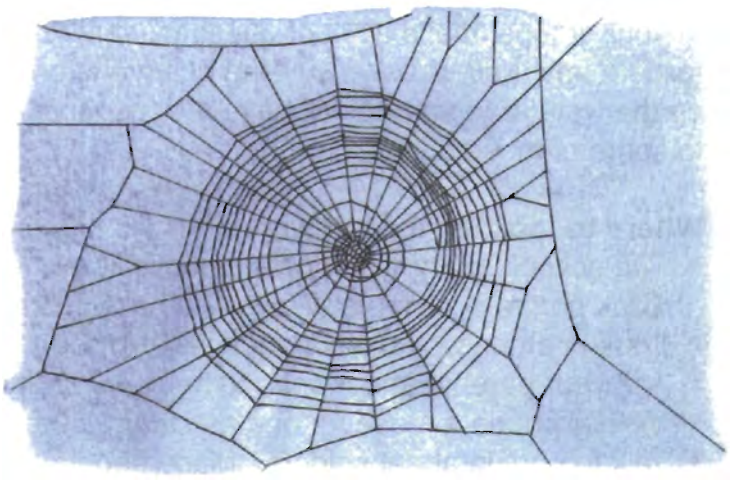
- Has it changed during this time? How?

Write a short report on what you have learned by looking at spiders and their webs.

University of Cape Town

The amazing silky web

Most spiders produce silk to spin their webs. They have special glands in their abdomens which produce this silk. Silk is the strongest, toughest thread known to man! This is a secret that spiders have that we have not yet been able to copy. They can make a waterproof protein thread which is five times as strong as steel and twice as elastic as nylon. Imagine how we could use a rope like this!



Orb web of garden spider

These same spiders can also make many different types of silk for the construction of their webs:

1. **Dry dragline silk** for the scaffolding of the web and the safety line which supports the falling spider.
   Imagine a bungie jumper strong enough to climb quickly back up his jump rope to the bridge like a spider can!

2. **Sticky silk** to trap the prey on the web.

3. **Wide ribbons of silk** to wrap up the captured prey.

4. **Fine silk** to spin nursery cocoons where baby spiderlings can hatch from their eggs in safety.

5. **Soft silk** to construct nests and retreats where even the bravest wasps cannot hunt them.

6. **Silk to line burrows** and to attach trap-doors that flip up to let the spider in and out of the burrow.



Funnel web



Hammock web

How do spiders use the webs above?

Spider silk is the envy of every silkworm in the world!

University of Cape Town

WHAT I CAN LEARN FOR MYSELF about web spinners

In your groups, make a list of questions that you would like to answer about spiders and their webs. Write the questions on a big sheet of paper and pin them on the wall. Each group will have the responsibility of finding out the answers to some of these questions.

Where to look for the answers:

- The school library or your local public library.
  Look on the shelves for Dewey number 595.4 - that section is about spiders.
- Look in an encyclopaedia under **arthropoda**, **spiders** and **arachnida.**
- Ask your parents and friends to help you find information about spiders.
- Visit or phone a museum and ask them if they can help you.
- Talk to people about spiders. Many people have learnt about spiders through their own experience.
- If you have a computer linked to the Internet, search for spiders or arachnida. (You can try http://thunder.sonic.net/~mk/work/spider.html)
- Share the answers to the questions you and your group found with your class.

EXPLORING SCIENCE HUNTING SPIDERS

'Spiders that hunt other insects move about a great deal. Usually we don't see them because most are very small and move about in the dark. These spiders love cool, shady and moist places like forests, gardens and indoors. Some spiders drink water, but most spiders depend on the moisture of the fluids in the body of their prey. Spiders that hunt help to keep the numbers of insects down.'

Is the above passage true? Can these statements be tested?

In your groups, discuss how to design experiments to test these claims.
Make a list of what materials you will need for the experiments.
Your group should write down and record all the steps in the experiment and everything that they see. The first step will be to find an area where spiders live.

Then test the following claims:

- Hunting spiders move around a great deal.
- Most hunting spiders are small.
- Most hunting spiders move about at night.
- Hunting spiders prefer cool, moist places.
- Spiders eat insects.

Your group can report back their findings to the whole class.

University of Cape Town

EXPLORING SCIENCE HOW TO COUNT MOVING SPIDERS



Spiders that hunt move around a lot. So if you try and count the spiders you see, you may count the same spider the next day. Here is a way of making sure that you don't count the same spider twice. When you see a spider:

1. Paint a tiny spot of acrylic (PVA) paint on top of the spider's abdomen.
2. Count the marked spiders.
3. Come back the next day.
4. Count all the marked and then all the unmarked spiders you find.
5. To calculate the spider population in the area:
   Total spiders = spiders seen on day 1 (marked)
   x spiders seen on day 2 (unmarked)
   ÷ spiders seen again on day 2 (marked).

Our Dangerous Spiders

There are about 4 000 species of spiders in South Africa. Most of them are harmless and do not have poison glands at all. Most of the spiders that have fangs can only scratch, but can't pierce the skin. In fact, most of the really fearsome-looking spiders are not dangerous! Big spiders can still give painful bites but only because they can take bigger bites. How do you think scary spiders' appearances help them?

The spiders shown in the pictures below are poisonous. Find out more about these spiders.



Button Spider



Sac Spider



Violin Spider



Baboon Spider

What to do if you are bitten by a spider:
If a spider bites you, there will be two marks on your skin. Try and find the spider that bit you. Put it in a jar and take it with you to the doctor. Don't ignore a spider bite! Some spider bites act quickly and we feel the pain soon after the bite. But some spiders, like the violin spider, have a painless bite which acts slowly but is poisonous. All the bites of these spiders shown above are very serious, whether there is pain and swelling or not. If you get bitten, put an ice pack on the spot, take pain killing medicine and go to a doctor as soon as possible.

University of Cape Town

WHAT I HAVE LEARNT about spiders

In your groups, discuss these questions about spiders.

- How is a spider different from an insect?
- Is it true that a spider has no head? Why?
- Can a spider fly through the air?
- Is it true that female spiders are usually smaller than male spiders?
- Why don't spiders need antennae?
- Is it true that spiders have one pair of eyes?
- Can spiders produce more than one type of silk?
- Is it true that the dragline is the spider's safety cord?
- What the best thing to do when you are bitten in bed while sleeping?

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

arachnida	A fear of arachnids, especially spiders
arachnophobia	The fused head and thorax region of the spider
cephalothorax	The group of arthropods to which spiders, scorpions and ticks belong - they all have eight legs
pedipalps	The feelers that are modified in some spiders to perform foot functions as well

University of Cape Town

WHAT I HAVE LEARNT about being a scientist

Scientists don't believe everything they read or see. They test claims by using experiments to prove the accuracy of these claims. We cannot expect to test everything ourselves this way, but we should be able to tell the difference between statements that are based on **opinions** and those that are based on **evidence**. Not all knowledge can be claimed to be **scientific knowledge**. Scientific knowledge can be experimentally investigated. Some of the most difficult questions have answers that cannot be proved by experimentation.

2.1 BRICKS THAT BUILD OUR WORLD

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe the different phases of matter.
2. Explain the particle nature of matter.
3. Understand the influence of different strengths of cohesive forces in the three phases of matter.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills in investigating Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify specific features of the three phases of matter.
2. Work together to answer investigative questions.
3. Demonstrate an understanding of the influence of cohesive forces in the three phases of matter.

Near misses!

US scientists warn of stray asteroids

More than 200 stray asteroids measuring more than one kilometre in diameter are roaming the solar system and some of them could cross the Earth's orbit. (Cape Times, 1/97)

Asteroid scrapes past Earth

Earth survived to see another day after an asteroid big enough to wipe out humanity whizzed past the planet. The asteroid named Tautatis (measuring 2km by 6 km) passed 5,3 million kilometres from Earth, a near miss when one considers that the Sun is 150 million kilometres away. The asteroid passes Earth once every four years. It has an orbit which changes and one day it might collide with us! If this were to happen, the impact would be powerful enough to cause an ecological disaster serious enough to destroy all life. Tautatis is only one of some 400 objects hurtling through space that could result in a terrible disaster on Earth. (The Star, 12/96)

University of Cape Town

Read these news reports. Can you draw a labelled picture to explain what happened? Then answer these questions:

- What do these newspaper reports warn us about?
- Can we do anything to prevent a crash between the Earth and an asteroid?
- If you were asked to investigate whether such crashes have ever taken place in the past, what evidence of such a disaster would you look for?



The asteroid Ceres is 758 km in diameter. That is about as wide as Botswana!

Asteroids and meteors

Asteroids are rocky objects which move in a path around a star in space. They can be very large. Meteors are much smaller and, like the Earth, move around our star, the Sun. Planets (like Earth), asteroids and meteors move around stars in paths called orbits because they are attracted by the huge force of gravity of the star. Orbits can be circular or elliptical.



The end of the terrible lizards?

A crash between Earth and another large body that also travels around the Sun is always possible. There have been several mysterious disasters on Earth millions of years ago which caused huge numbers of animals and plants to die out. There is evidence that Earth was hit by large ***asteroids*** which caused huge explosions.

These explosions would have resulted in thick clouds of dust and gases. The clouds would have reflected the sunlight away and cooled the Earth down to below freezing point. In this Ice Age, most of the dinosaurs would have been killed.

It has taken us thousands of years to understand our world. One of our most important understandings has been our knowledge of the nature of ***matter*** - the building bricks of our world. Life on Earth is found in matter - the ***air*** (a mixture of ***gases***), ***water*** (a ***liquid***) and ***land*** (a ***solid***). To understand how life is possible in these different materials, we need to explore the properties of solids, liquids and gases.

University of Cape Town

EXPLORING SCIENCE MODELLING MATTER

Work in groups. Push your desks back to clear a flat surface on the floor.
Each group will need:

50 marbles or a cup of dried whole peas;
some plastic containers of different shapes.

1. Pour the marbles or peas out onto the floor.
   - Do they form a pile? Describe what happens.
2. Try to build a pyramid.
   - What happens? Why is it so difficult to do this?
   - What would you have to do to build a pyramid?
3. Pour the marbles or peas into different shaped containers.
   - What determines the new shape of marbles or peas?
   - Why is the shape different every time?
4. Choose a container that has a lid. Fill the container to the top with marbles or peas. Close the lid. Hold the lid down firmly. Squeeze the container between your hands.
   - What happens? Can you push the sides of the container together?
   - What prevents you from doing this?
5. Try to repeat step 4 with water.
   - What have you learnt about liquids?

What we know about matter

Every physical object is made of something.
We call this something - ***matter***. Matter exists as **gases, liquids** or **solids**. These are the **three phases of matter**.

If enough heat energy is transferred to any solid, it will melt into a liquid. If the liquid is further heated, it will boil and then turn into a gas. The transfer of heat energy to or from matter is needed to change the phase of matter. For example, if heat energy is transferred to water (a liquid), it will change into a gas (water vapour). If heat energy is transferred to ice (a solid), it will change its property and become a liquid (water).

The properties of matter, which may be changed by the transfer of heat energy, are called **physical properties**.

All matter consists of tiny invisible particles called **molecules**. These particles move about. This particle movement is heat energy.

In matter, there are small forces attracting molecules together. These tiny forces of attraction are called **cohesive forces**. These forces cause molecules of matter to stick together.

The properties of water



solid (ice)



liquid (water)



gas (water vapour)

University of Cape Town

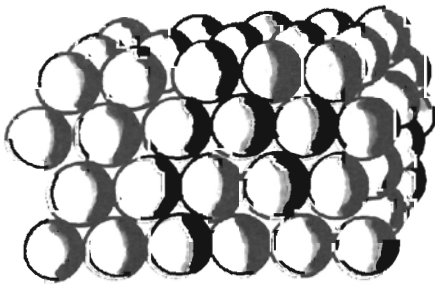
EXPLORING SCIENCE MEETING SOLIDS

You will need: some hard, solid things like a brick or some stones.
Use these solid objects to answer these questions in your groups:

- Has a solid always got one shape or not?
- Can you change the shape of a solid easily?
- What will it take to break a solid into smaller pieces?
- Can you push your finger into a solid?

What we know about solids

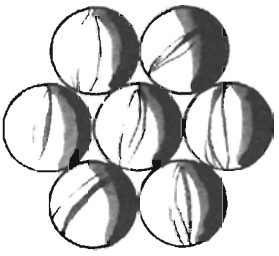
All solids have a definite shape. It is usually difficult to change the shape of a solid or break it into smaller pieces. If we want to push anything into a solid we have to push the particles of the solid apart to make room for it. This may take a lot of energy!
The cohesive forces in solids are very strong. These forces lock the particles into fixed positions according to a pattern which repeats itself over and over.

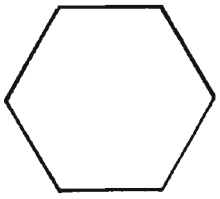


EXPLORING SCIENCE REPEATING PATTERNS IN SOLIDS

Use your marbles or whole dried peas and pack out a single layer on any flat surface. They must be in contact with each other.

- Can you see any repeating pattern? Describe the pattern.
- How many marbles or peas are in the pattern?





EXPLORING SCIENCE LIQUIDS ARE DIFFERENT FROM SOLIDS

For this investigation you will need:
some differently shaped containers, a large syringe, a bicycle pump or a soft plastic cooldrink bottle

Pour some water onto a flat surface and then into each of the containers.
Ask yourself: What is happening to the invisible particles in this water?

Hint: think of the marbles!

- What happens when water is poured out onto a flat surface?
- Does water always have one shape?
- Does water have a surface?

1. Push your finger into the water and move it around.
   - Was it difficult to put your finger in the water?

2. Push all of the air out of the syringe (or bicycle pump) and suck water into it until it is half-full. Place your finger on the outlet. Squeeze the water in the barrel by pushing on the plunger.
   - What happens? Can you push the plunger down?

3. Or completely fill the plastic bottle with water and screw its top on tightly. Then put your hands around the bottle and squeeze the bottle.
   - Can you get the same amount of water to fit into a smaller space?
   - Can you squeeze the sides of the bottle together?
   - What have you learnt about the difference between solids and liquids?



University of Cape Town

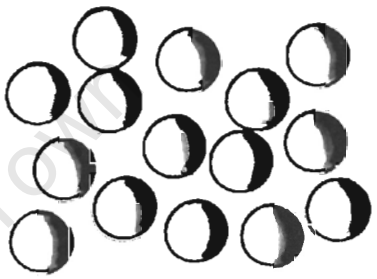
What we know about liquids

When water is poured onto a flat surface it does not form a pile of water. It flows until it forms a thin layer. This is because liquids do not have any fixed shapes like solids. Liquids take up the same shape as the container they are in. Liquids always have an upper surface. Look at this picture of a lake. The lake's water takes the shape of the valley it lies in. The upper surface of the lake is the water we can see.



A lake is a body of water that takes the shape of the valley it lies in

It is easy to push liquid particles apart. You can put your finger into the water and move your finger around. It is very difficult to squeeze water particles into a smaller space. In liquids, the cohesive forces are much weaker than in solids. Liquid particles do stick together and touch each other. They can also move passed each other easily. They are not locked into fixed positions. There is not much unused space between water particles, which is why it is hard to compress water into a smaller space.



EXPLORING SCIENCE GASES ARE DIFFERENT FROM LIQUIDS

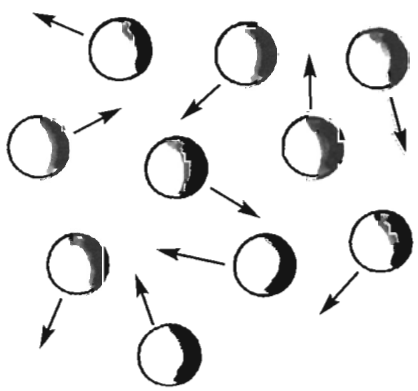
You will need:

a syringe, bicycle pump or a plastic colddrink bottle with a screw top.

1. Put your finger on the outlet of the pump (or syringe) and squeeze the gas by pushing the plunger in hard. Or close the bottle, put your hands around it and squeeze it.
   - Can you squeeze the gas into a smaller volume?
2. Close the window and door and spray some air freshener into the room at one corner. Put your hand up when you can smell the freshener from the other side of the room.
   - What did you notice?

What we know about gases

In gases, the cohesive forces are very weak compared to those in solids and liquids. Gas particles move very fast and easily. They can move at about 1 600 kilometres per hour at room temperature! This enables them to fill a large container (like a room) very quickly. Only a huge force can cause them to stay together in one place. Earth's gravitational force is large enough to hold the gases of our atmosphere in place at the Earth's surface. Life is possible on our Earth because there is air on the surface for us to breathe.



University of Cape Town

WHAT I HAVE LEARNT about matter

Are the statements below true or false?

1. Solids cannot be compressed.
2. Gases consist of closely packed particles.
3. The force which holds particles together is strongest in solids.
4. It is easy to push gas particles closer together.
5. A liquid takes on the shape of the container that it is in.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

asteroid	A rocky body which orbits the Sun
cohesive forces	Forces of attraction between particles in matter
meteor	The path followed by an object around a star
orbit	A rocky body which orbits a star

WHAT I HAVE LEARNT about the tools of science

Scientists often use **models** to explain real phenomena. Models are well-understood descriptions and explanations of what we know, which are used to explain or describe new information we are struggling to understand.

Scientists will say that matter behaves **as if** it consists of particles; gases behave **as if** the particles are far apart. So models allow scientists to gather valuable information about events or things they don't understand completely.

University of Cape Town

2.2 THE UMBRELLA OF LIFE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe the structure of the atmosphere.
2. Explain the role of the atmosphere in the control of Earth's temperature.
3. Explain the origin of acid rainfall.
4. Understand that the control of emissions from power stations is very complex.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills in investigating Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO8 Demonstrate knowledge and understanding of ethical issues, bias and inequities related to the Natural Sciences.
NS-SO9 Demonstrating an understanding of the interaction between Natural Sciences and socio-economic development.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify specific features of the three phases of matter.
2. Work together to answer investigative questions.
3. Debate the issues involved in controlling greenhouse emissions.
4. Debate the effects of increased global temperature.
5. Show an understanding of the effect that the availability of electricity has on society.

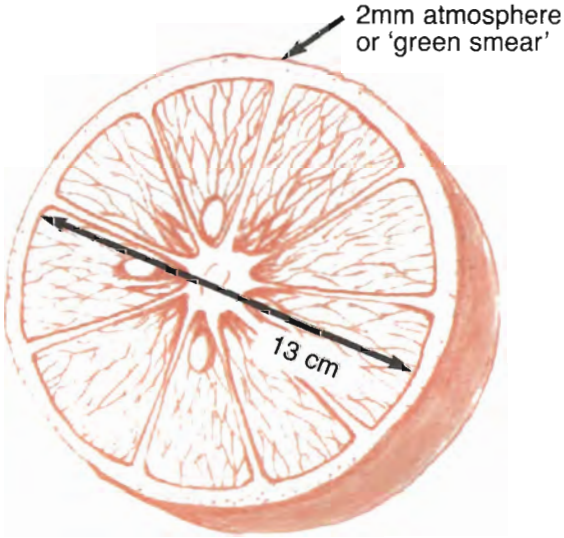
Mars, here we come!

Washington:
President Clinton today announced that Americans will be living on Mars by the year 2020. Fifty pioneering couples will, like the colonists of old, tame this wild world for the rest of us. He predicts that tourists from earth will be streaming to Mars to enjoy the great outdoors.

Do you think this claim could ever come true? As far as we know, life only occurs on Earth. Do you think we can ever live on Mars? Why not? What is so special about Earth?

Earth is the third planet from our Sun. Mars, our nearest neighbour, is the fourth planet. Earth is beautiful from space. It consists of a solid part (land) and a liquid part (water, mainly oceans). Our planet is covered by a layer of gas called the **atmosphere**. Liquid water and a breathable atmosphere are the main differences between Earth and Mars. Mars has neither! Air, liquid water and green plants together make life possible on Earth. Some ecological scientists describe the region in which life exists here (the oceans, land surface and atmosphere) as a 'thin green smear' on the planet.

If Earth was reduced to the size of a 13 cm orange, the 'green smear' would be a layer only two millimetres thick over the surface of the ball - as thick as an orange skin. The gas layer or atmosphere is part of the thin skin of life. The atmosphere is thickest near the Earth's surface and becomes thinner the further away from Earth we go. All life occurs in the bottom 10 km of the gas layer closest to Earth, on the land and in the oceans.



Mars is smaller than Earth. Mars has a weaker gravitational force, and it is unable to trap much gas around it. It has a very thin atmosphere and cannot sustain life as we know it.

University of Cape Town

Look at this photo Mars taken from space. Compare it to the photo of Earth below.



Answer the following questions:

- Why is the space around Earth and Mars black?
- Why is the Earth blue in colour?
- What are the white parts that seem to float above the Earth?
- How much of the photo of Earth shows solid land?
- Make a list of the differences between Earth and Mars.
- What are the 'bumps' on Mars? How do you think they were produced?
- Why doesn't Earth have 'bumps' on it?

The Umbrella of Life

The atmosphere of Earth is held in place by the force of attraction of the Earth (**gravity**).
The Sun's energy strikes the gas particles so that they move around all the time.
Our atmosphere is a mixture of gases, mainly nitrogen and oxygen.
Nitrogen is important in the natural production of nitrate plant foods (fertilisers) formed during lightning storms and by bacteria in the soil.
Oxygen is the gas which causes iron to rust and wood to burn.
Most living organisms need to breathe oxygen to stay alive.



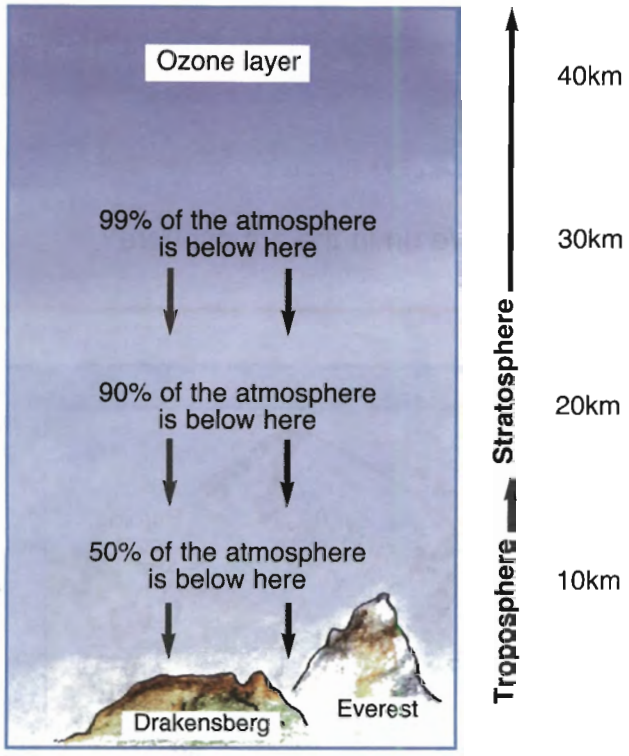
Study this photo of Earth taken from space.

The photograph shows that the atmosphere contains not only gases, but also clouds made up of very small drops of water. At any one time, about half of Earth is covered by clouds. Clouds are formed by water drops held in the atmosphere around solid particles like dust and salt.

Further away from Earth's surface, the atmosphere gets thinner until it disappears in the emptiness of space about 2 000 kilometres up.
The **atmosphere** of Earth is mainly made up of two layers: the **troposphere** and the **stratosphere** just above it.

These two layers determine weather patterns and climate. They have the biggest influence on all life on Earth. The troposphere reaches up about 17 kilometres above the surface of Earth. Most human activities take place in the lower two kilometres of the troposphere.

University of Cape Town

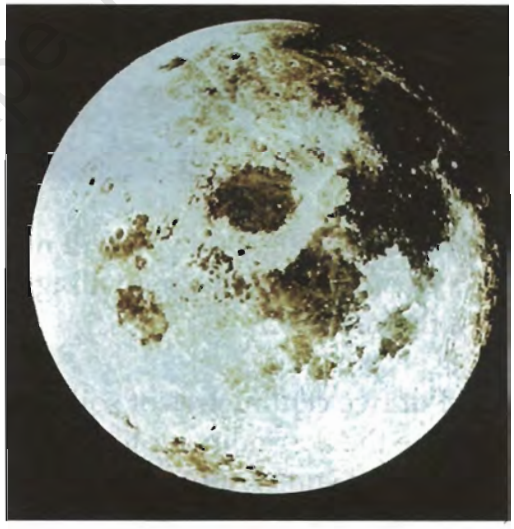


1 kg of air at sea level (where the air is thickest) consists of:

750 g nitrogen gas
230 g oxygen gas
6 g water vapour
13 g argon gas
1 g of carbon dioxide gas

Losing the umbrella of life

Study this photo of the moon.



Imagine Earth without any atmosphere. Our moon gives us some idea of what it would be like.
The moon gets very hot (up to 100°C) and very cold (down to -150°C). The average temperature on the surface of the moon is -18°C. That is very cold!

On Earth the temperature varies from -50°C up to 48°C, with an average temperature of 15°C.
So on average, Earth is much warmer than the moon.
The warming effect of an atmosphere is called **the greenhouse effect.**

Our solar system is a 'family' of planets with a star (our Sun) as its gravitational centre.
There are nine planets in our solar system. Mars is further from the Sun than Earth is.
It has a very thin atmosphere so it cannot trap much heat energy from the Sun.
Mars is a very cold planet with a surface temperature of -123°C to -30°C!
Between the orbits of Mars and Jupiter there is an asteroid belt or group.
This is where some of the wandering asteroids come from that have near misses with neighbouring planets or else collide with them, causing catastrophes.

In your groups:

- Find out the names and positions of all nine planets in our solar system.
  Make a chart which shows all the planets and their relative distances from the Sun.
  Start by drawing the Sun on the left hand side of the board.

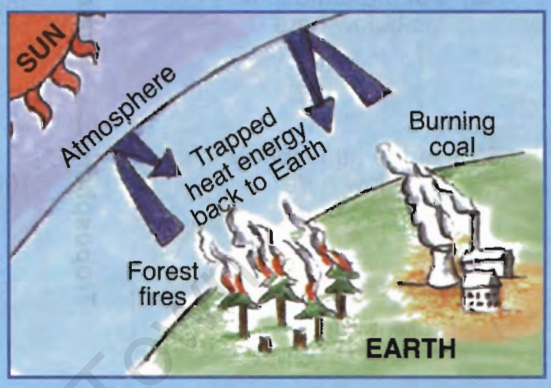
University of Cape Town

WHAT I HAVE LEARNT about the atmosphere

1. How much of the atmosphere is below six kilometres?
2. How much of the atmosphere is below 30 kilometres?
3. At what height does the ozone layer start?
4. What happens to the temperature of the gas as we move up in the atmosphere?

The Greenhouse Effect

By day, heat energy from the Sun warms the surface of the Earth. At night the warm Earth loses heat energy into the colder atmosphere. This escaping heat is trapped in the atmosphere by water vapour and carbon dioxide. These are the greenhouse gases. By trapping the heat energy which is reflected back to Earth, these gases are causing our planet to become slowly warmer.



EXPLORING SCIENCE INVESTIGATING THE GREENHOUSE EFFECT

For this investigation you will need:
a glass bottle, some modelling clay (plasticine) and a thermometer.



1. Put five centimetres of soil into your bottle.
2. Use the thermometer to find the temperature of the air in a sunny spot. Write the temperature down.
3. Use the clay to close the bottle. Push the thermometer through the clay, so that its bulb is about halfway down the bottle.
4. Put the bottle in the sun and take a thermometer reading every five minutes for about 30 minutes. Keep a record of the temperature readings.

- What happens to the temperature of the air inside the bottle?
- What is the temperature of the air outside the bottle?
- Is the air outside the bottle warmer or colder than the air inside the bottle?
- Could the air outside have heated the air inside the bottle?
- How did heat get into the bottle?

University of Cape Town

EXPLORING SCIENCE ADDING TO THE ATMOSPHERE

For this investigation you will need:
two glass bottles, two lengths of wire, two small lumps of coal, limewater ($Ca(OH)_2$), black tea, a lemon and modelling clay (to use as bottle stoppers) and a candle.

1. Wrap one end of each of the wires around a lump of coal.
2. Remove the stoppers. Push the free end of the wire through the stopper from the bottom end and pull it upwards until the coal hangs about two thirds of the way down in the bottles.
3. Pour some black tea into a container (a test tube, cup or plastic bottle) and add a few drops of lemon juice to it.
   - What happens to the colour of the tea?
   - What does lemon juice taste like?
4. Pour half a cup of tea into one of the bottles. Pour the same amount of limewater into the other bottle.
5. Pick up a stopper (with wire and coal) and light the coal using the flame of a candle.
6. Lower the burning coal into the bottle containing limewater. Close the bottle and allow the coal to burn out.
7. Keep the stopper on the bottle. Shake the bottle to mix the gas with the limewater.
   - What happens to the limewater?
8. Repeat steps 7 and 8 with the bottle containing tea.
   - What happens to the colour of the tea?
   - What substance must be present in the liquid to bring about this change?
   - What two substances are produced when coal burns in air?



The Killer Rains

When coal burns, it gives off ***carbon dioxide*** gas and acid into the air. This acid is usually ***sulphuric acid*** (from the sulphur which is present in coal). Today, we have become very dependent on electricity. To generate most of our electricity we need to burn coal or oil. When we burn oil and coal (fossil fuels), they give off large amounts of acids and carbon dioxide (CO_2). These gases mix in the atmosphere and come back to the earth in acid rain. These acid rains are dangerous and can kill fish and trees.

Exhaust gases produced by motor cars do this as well. Every ton of coal we burn produces four tons of carbon dioxide gas. Since 1980, 20 thousand million tons of carbon dioxide have been added to the atmosphere. Half of this dissolves in the oceans or is used by plants. In 1850, there were about 270 carbon dioxide particles in a million air particles. In the 1990s, there are about 350. Carbon dioxide is a greenhouse gas! Since 1850, the average global temperature has increased from 14,7°C to 15,2°C.

University of Cape Town

WHAT I HAVE LEARNT about the greenhouse effect

In your groups, answer the following questions:

1. What effect will the increase in carbon dioxide in the atmosphere have on the Earth's average temperature?
2. What may happen here on Earth if our atmosphere gets too hot?

WHAT I HAVE LEARNT about the atmosphere

Are these statements true or false?

1. We live in the part of the atmosphere called the stratosphere.
2. The atmosphere is warmed by the greenhouse effect.
3. Oxygen is a greenhouse gas.
4. Acid rain is caused by burning coal to produce electricity.
5. The carbon dioxide in the atmosphere is increasing.

Remember these new ideas

We have learnt many new words. Select their meaning from the list below and then add them to your Natural Science dictionary

atmosphere	The layer of gas around the Earth
troposphere	The warming of the atmosphere by reflected heat
stratosphere	The part of the atmosphere in which we live
greenhouse effect	The part of the atmosphere starting about 10 km up
acid rainfall	Produced when products of burning coal dissolves in rain water

WHAT I HAVE LEARNT about the tools of science

Scientists often apply the knowledge which they have gained through investigations in laboratories to events in the outside world.

When faced with the fact that humanity is burning increasing amounts of oil and coal (fossil fuels), scientists can predict that carbon dioxide gases are being added to the atmosphere. Scientists have tested this idea and found it to be true. This fact allows scientists to predict that the atmosphere will get warmer. Scientists disagree about the effects of planetary warming on living organisms. It could be either good or bad for life on our planet.

University of Cape Town

2.3 THE WATER WORLD

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Calculate the force exerted on every square centimetre of any water surface at a given water depth.
2. Explain the role of water in regulating the temperature of nearby land surfaces.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills in investigating Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Calculate water pressure in terms of atmospheric pressure.
2. Work together to answer investigative questions.
3. Demonstrate an understanding of the temperature moderating properties of water.

Squid hunting in the dark

With one last great puff of moist air, the great sperm whale disappeared down into the blue-green ocean. A hundred metres down, the water was already bluer, darker and colder. The squeezing pressure of tons of water forced in on the whale from all directions. The air in its great lungs compressed into its nasal passages and trachea.

The whale felt less buoyant... it began to sink more rapidly. In the rapidly gathering gloom and darkness, it sank down through the thermocline - the invisible border between the warm surface water and the cold deep water worlds. The whale didn't feel the change in temperature. The great fat deposits of blubber protected it from the cold and the increasing pressure.



Minutes later, two kilometres below the surface, the sperm whale was in total darkness! No light had ever reached this great depth. The huge external pressure of 200 atmospheres (200 kg/cm^2) forced its body into another leaner, meaner shape. It swept the darkness, sonar clicking... and something bounced back... the hunt had begun!

Close by, in these great deeps, lurked its terrible prey, the giant squid, an animal strong enough to crush a small whale. The fearless hunter surged towards the sound echoes bouncing back from the tentacled monster. The great squid, knowing no fear either, turned its whips and arms lined with suckers and hooks towards the pressure wave surging towards it out of the icy darkness.

University of Cape Town

Discuss this story in your groups.

- What does it tell you about life conditions below the surface of the ocean?

Water

Water is a liquid formed from two gases: hydrogen and oxygen.

- 67% of the Earth's surface is covered with salt water oceans.
- 75% of the Earth's surface is covered with water in all its forms, including ice and fresh water.
- 1 cubic kilometre of water weighs 1 million tons.
- 1 300 million cubic kilometres of water is present on the surface as liquid water and ice.
- 8 million cubic kilometres of water is found underground.
- 1 300 cubic kilometres of water is in the atmosphere in the form of water vapour (mainly clouds).



EXPLORING SCIENCE THE SQUEEZING PRESSURE OF WATER

For this investigation you will need:
a deep see-through container (or a 1000 cm^3 measuring cylinder), three straws, a stick (about one metre long) and a test tube or a see-through pill container.

1. Fill the container with water. Push a straw into the water as deep as possible. Blow into the straw. You will find that it is hard to blow bubbles into the water!

2. Now make a straw three times longer than the first one (by joining all three straws together and sealing their joints with sticky tape). Blow again into the water through this longer straw.
   - Why is it be more difficult to blow bubbles through the longer straw?



3. Attach the inverted test tube (or pill container) to the end of a stick and push it down into the water.
   - What happens to the size of the air bubble in the test tube as you push it down?
   - Why do you think this happens?
   - How does the force with which the water pushes against the air bubble change as it descends to a greater depth?
   - How do you think this force affects the sperm whale in our story, ***Squid hunting in the dark***?

University of Cape Town

Squashed by water!

If you push your head under water, you can feel water pushing in against your ears. Deep in the sea, this increasing pressure becomes very painful. Plants and animals which live in deep water cope with this pressure in different ways.

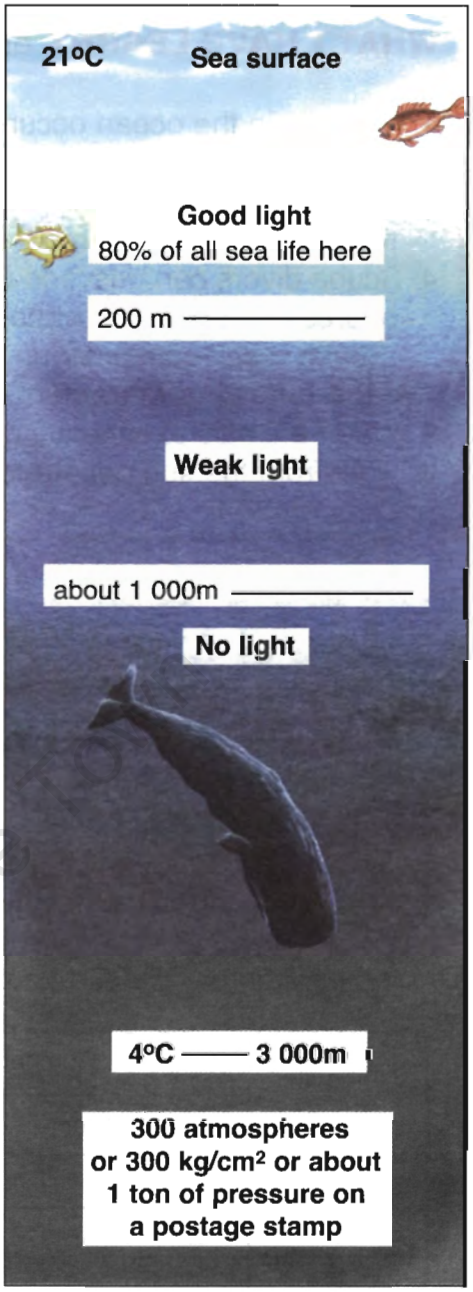
The sperm whale dives down to depths of up to 2,5 kilometres to find squid. No other animal can do this and live! The body of the sperm whale enables it to survive this deep dive. It has strong wax ear plugs, ribs which fold under high pressure, lots of protective body fat and muscles which can store huge amounts of oxygen.

Look at the diagram on the right and then answer these questions:

- How many atmospheres of force act on each square centimetre of a whale at 2,5 kilometres depth?
- What will happen to the volume of gas in a whale's lungs as it descends down in the ocean?

The deepest part of the ocean is the Mariana Trench in the Pacific Ocean. It is 11 kilometres deep!

- How many atmospheres of pressure act on animals living at the bottom of this trench?
- How do you think these huge forces might affect the way in which ocean animals' bodies are designed?



An atmosphere of pressure

Imagine a pipe that is one square centimetre (1 cm²) wide. Imagine that this pipe is very long and can reach far up to the top of the atmosphere. The air pressure inside this pipe would be one kilogram. This is called one atmosphere of pressure.



The weight of the atmosphere pushing on every square centimetre of any surface, including our bodies, is called **atmospheric pressure**.

One kilogram of water in the 1 cm² pipe would fill the pipe to the 10 metre level.
This means that for every 10 metres we go below a water surface, we add one kilogram more pressure to every square centimetre of our body surface i.e. one extra atmosphere.

University of Cape

WHAT I HAVE LEARNT about living underwater

1. Most life in the ocean occurs above _____ metres.
2. What is meant by the term **atmospheric pressure**?
3. The force on each square centimetre of an object at the surface increases _____ times for each 10 metres it sinks below the surface.
4. Scuba divers can descend down to about 300 metres. How many extra atmospheres of pressure does the scuba diver experience at this depth?
   (Scuba = self-contained underwater breathing apparatus).

Are the following statements true or false?

5. Water animals experience greater forces on their bodies than land animals.
6. Light from the sun penetrates to the floor of the oceans.

EXPLORING SCIENCE IT IS DIFFICULT TO WARM UP WATER

In this investigation you will handle hot liquids, **so be very careful!**

You will need: a pot of boiling water, a thermometer,
two identical glass beakers or cups (one half-filled with cold water,
and one half-filled with cold cooking oil).

Draw the following table in your workbook:

Time in minutes	Temperature in °C of:	
	Water	Cooking oil
0		
1		
2		
3		
4		
5		

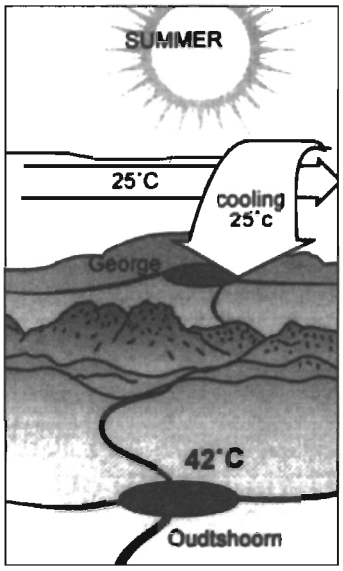


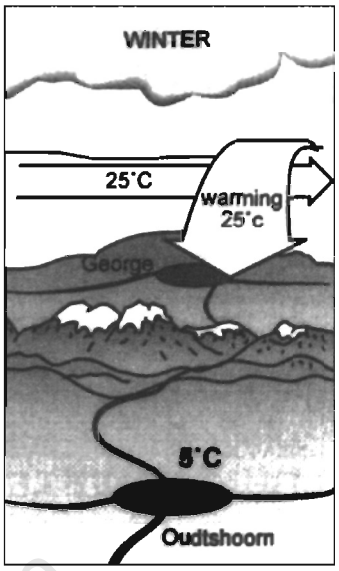
1. Using the thermometer, take the temperatures of the liquids in the two cups.
2. Record the values in your table next to each for *time = 0* minutes.
3. Place the beaker with water in the pot of boiling water. Stir the contents with the thermometer and read the temperature every minute for five minutes.
4. Repeat the above steps with the cooking oil.
5. Record the data of your results for each liquid separately.
6. Study your data table and answer these questions:
   - Which liquid changed its temperature most?
   - Which liquid changed its temperature least?
   - Which liquid changed its temperature most rapidly? Why did this happen?

University of Cape Town

Holidays at the coast

It takes a lot of heat energy to warm water. The ocean absorbs large amounts of the heat from the air, but it is hardly warmed up by this at all. During the summer days, the land warms up quickly in the sunshine. Heat energy moves up into the air above the land.





Oudtshoorn in the Karoo gets as hot as 42°C in summer.
George on the coast is nice and cool on the same summer days at 25°C. The ocean air helps to cool it down.

When winter comes, the cooling ocean transfers large amounts of heat to the air and coastal areas. George is still about 25°C, but inland at Oudtshoorn it can get much colder at 5°C .

Average daily highs	February	July
Oudtshoorn	42°C	5°C
George	25°C	25°C

In your groups:
Look at these maps above and try to explain why cool sea air doesn't reach Oudtshoorn in summer.

University of Cape Town

WHAT I HAVE LEARNT about water and temperature control

In your groups, discuss answers to the following questions:

1. Are these two statements true or false?
   - Water animals experience greater temperature changes than land animals.
   - It is easy to change the temperature of water.

2. Once or twice in winter the temperature at Cape Town may fall below the freezing point of water (0°C); while in Bloemfontein the temperature often reaches below freezing point. Why does this happen?

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

(200) atmospheres	To become weightless when submerged in a fluid
buoyant	The number of times greater (200x) than the weight of the atmosphere, per square centimetre, at the surface

WHAT I HAVE LEARNT about the tools of science

Scientists compare properties of materials under controlled conditions. When a scientist wants to compare the temperature changes for a number of different materials when heated, he or she will start the investigation by asking questions about which factors may affect the change in temperature. For example, they ask questions like:

- How much of each material is there?
- What is the temperature of the warming agent?
- How long will each material be heated?

These three factors will then be kept the same for all the different materials under study during the investigation. This is what you did when you investigated temperature changes in water and cooking oil. This is known as **controlling all the experimental variables** (the different factors which affect the results).

University of Cape Town

2.4 THE SHIFTING CRUST

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe the internal structure of the Earth and understand the movement of the crust.
2. Understand how folding and earthquakes occur.
3. Explain how land forms originated.
4. Grow a crystal.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills in investigating Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-S07 Demonstrate an understanding of the changing and contested nature of knowledge in Natural Science.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify specific features of the structure of the Earth.
2. Work together to answer investigative questions.
3. Grow a crystal.
4. Describe the cause of earthquakes.
5. Describe the origin of different types of local rocks.
6. Explain why the ideas of the Earth's core and Gondwanaland are speculative.

When the Earth moves



On the 29th of September, 1969 at 22h05 the Western Cape towns of Tulbagh, Ceres, Wolseley and Prince Alfred's Hamlet were almost destroyed by an earthquake. Here is an eyewitness account of the event:

"And then, suddenly, while I am still talking, it happens... without any warning or prior indication... the earth starts to shake and rumble! In the kitchen and in the rest of the house everything starts to shake and to shiver... faster and faster... and harder and harder! An appalling noise, a roar and a rattle, an overwhelming sound of the mountains being torn open makes us look at each other in fear. Cupboard doors fly open and bottles of jam, cups, saucers, glasses, plates and ornaments are thrown wildly through the air before they shatter into pieces on the floor with a loud clatter. The whole house starts to topple. Suddenly it is pitch dark.

Andrew falls from the kitchen table and clings onto Clement's leg for dear life. We have no control over ourselves and find that we cannot move at all. We are tossed to and fro and cling with all our might to the table, which is being jerked backwards and forwards. My husband is flung from the bed and crawls outside to see what on earth is happening. Conflicting thoughts flash through the shocked silence of my brain... What can it be?.. No! Surely not... Judgement Day? We are still so young and life is so beautiful, so full. There is still so much to be done!"

T. Cillie, *Die Aarde het Gebewe*, 1971

This earthquake rocked the Breede River Valley and was felt all over the Western Cape, as far as Cape Town.

In your groups, discuss what you know about the origin of earthquakes.

- Why do earthquakes happen?
- Why do there seem to be so many earthquakes in some places and so few in others?
- What the safest thing to do during an earthquake?

University of Cape Town

The foundation of our Earth home

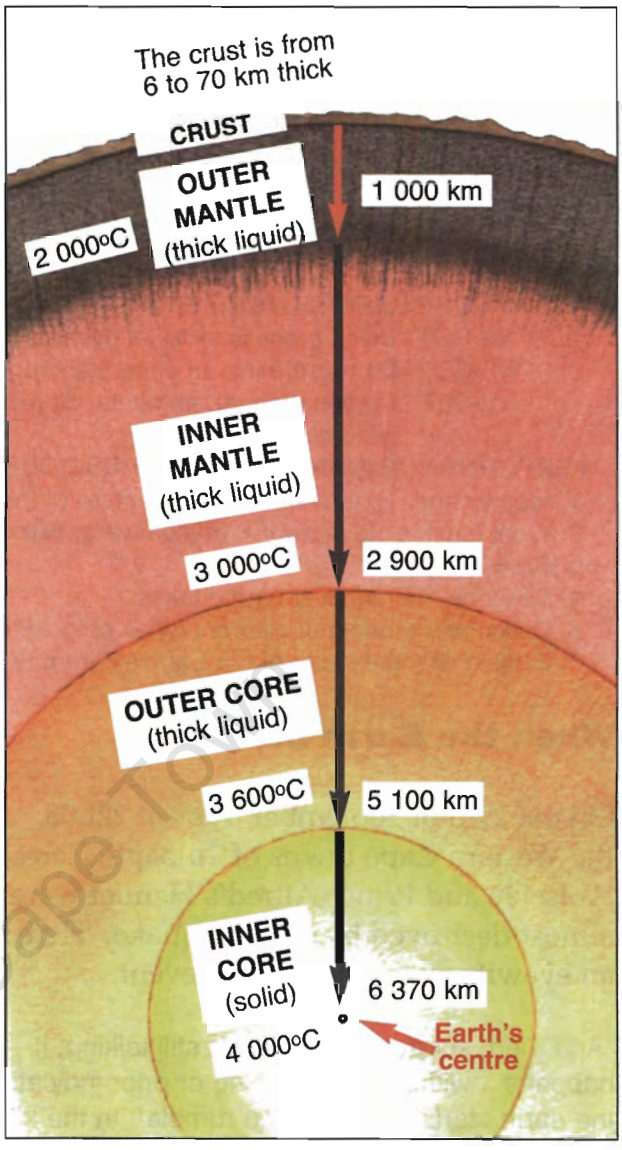
Our planet, Earth, is a sphere. It is rather like an onion, made up of layers.
Earth has four main layers:

the **crust**,
the **mantle**,
and the **outer** and **inner core**.

The crust is the thin outer solid layer.
Its thickness varies from six to 70 kilometres.
The crust is so thin that if Earth was a giant onion, the crust plane of Earth would be thinner than the skin of the onion.
We live on this delicate crust.
It is mostly made up of rock.

The Earth's skin is not smooth. In places, it is wrinkled and folded like the blankets on a bed. The next layer down from the crust is called the mantle. It extends from the bottom of the crust down to a depth of 2 900 kilometres.

The outer parts of the mantle are made up of molten rock which forms a liquid rather like a thick syrup. The crust floats on this hot liquid rock. The outer part of the core is also liquid rock, but the inner core is a very hot solid made up of a mixture of iron and nickel.



University of Cape Town

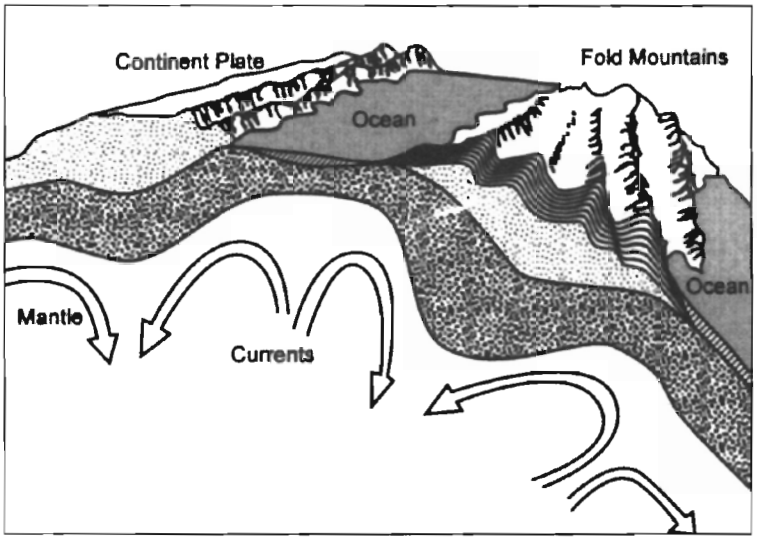
WHAT I HAVE LEARNT about the Earth

In your groups, discuss the following questions:

1. What is the radius of the Earth in kilometres?
2. How does the temperature of the Earth change as one descends from the crust towards the core?
3. What is the temperature range of the outer mantle?
4. What is the physical state of the inner mantle?
5. What is the temperature of the inner core of Earth?
6. What is the physical state of the inner core?

Why the crust moves

Temperature differences inside the Earth cause **convection currents** in the liquid mantle. When the liquid rock moves past the bottom of the crust it drags the crust, especially where the crust is thin. This builds up huge stress forces within the crust. The crust may buckle, break or move.



If the crust folds downwards, we call the down fold a **syncline**. If the crust folds upwards, we call the up fold an **anti-syncline**.

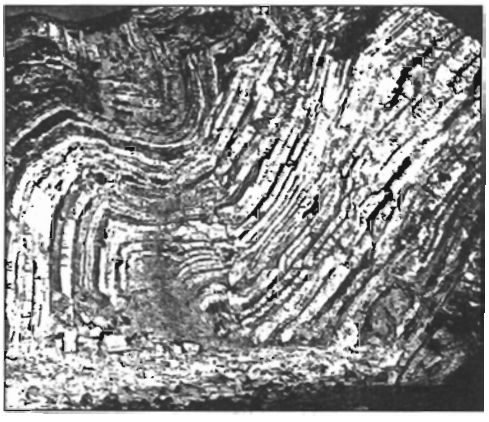
Mountain ranges like the Southern Cape coastal ranges and the Drakensberg were formed in this way. Sometimes the crust cracks. We call this a **fault**. When two sides of such a fault move in opposite directions slowly, earth tremors occur. Earthquakes happen when the two sides of any fault slip suddenly past each other.

University of Cape Town

EXPLORING SCIENCE THE MOVING CRUST

For this investigation, you will need:
three differently coloured strips of modelling clay (plasticine) and two rulers.

1. Roll each of the three modelling clay strips into a layer about 20 centimetres long and 10 centimetres wide.
2. Place the three layers of clay on top of each other.
3. Place a ruler at each long end of the clay.
4. Hold one ruler still and slowly push the other ruler towards the stationary one until it has moved about five centimetres.
   - What happens to the clay?
   - Make a drawing of the clay after it has been squeezed.
5. Continue to squeeze the clay. Make a series of drawings to show what happens after shifts of 10 and 15 centimetres.
6. In your groups, discuss what the clay has taught you about the way fold mountains are formed.
   - Where would you expect cracking or faulting to occur?
7. Study the photograph on the right. Explain what happened to the Earth.



Convection currents in the outer mantle can cause the Earth's crust to fold

The hard stuff under our feet

Igneous rocks:

The Earth's crust formed many millions of years ago as the Earth cooled down. Sometimes hot liquid from the outer mantle may leak out through weak spots in the crust. This is what happens when a volcano erupts! The molten rock liquid (magma) that comes out from the outer mantle through the crust is called **lava**. When lava cools down it forms hard rock. Rocks formed in this way are called **igneous rocks** (fire rocks). When magma flows out through a fault onto the surface, it cools down very rapidly and forms a black glass called obsidian.

But if the magma leaks into gaps between rocks deep below the surface, it cools down slowly. These slow cooling rocks have large crystals and are called **granites**. Granite is a very common rock in South Africa. We can tell how quickly the magma cooled down by the size of the crystals in the igneous rocks. When it cools down fast, it forms small crystals, such as **basalt**. Metals, such as gold, form in some of these igneous rocks.

Sedimentary rocks:

When igneous rocks are broken down by the action of wind, water and temperature changes at the surface, they break up into small pieces. These little pieces of rock may be carried by wind or water to form layers of mud under water. These layers harden over time and form rock sediments (**sedimentary rocks**). If the layers consisted of sand pieces, the rock is called **sandstone**. Table Mountain consists of flat, unfolded layers of sandstone. If the layers consisted of clay pieces, the rock that is formed is known as **shale**.

Metamorphic rocks:

Coal is formed mostly from carbon. **Limestone** is formed from layers of crushed shells from sea and swamp creatures and is mostly calcium carbonate.
When hot magma leaks into a bed of sedimentary rock, the heat causes the sedimentary rock to change. Such rocks are called **metamorphic rocks** (changed rocks).
Slate is metamorphosed shale. **Marble** is metamorphosed chalk. All rocks, except rocks which have formed from the remains of once-living organisms, come originally from igneous rocks.

University of Cape Town

WHAT I HAVE LEARNT about the formation of rocks

In your groups, discuss the following questions:

1. What are igneous rocks?
   How do they form?
2. How do sedimentary rocks form from igneous rocks?
3. **Challenge**: Coal forms from the remains of living organisms.
   How does this happen?

EXPLORING SCIENCE MAKING ROCKS

Igneous rock crystal structures form through slow or rapid cooling.
Let's see how this works. You will need:
water, salt, sugar, a container to heat water and
two containers (the bottoms of plastic bottles will do) to cool the solution in.

1. Make a warm solution of sugar or table salt. Add the sugar or salt until the solution is saturated (when no more sugar or salt can dissolve into it).
   Pour half of the solution into each of two containers.
   Place one container in a dish of hot water and allow it to cool slowly.
   Place the other container where it can cool more quickly near an open window.
   - How big are the crystals that form in each case?
   - How does the speed of cooling affect the crystal size?

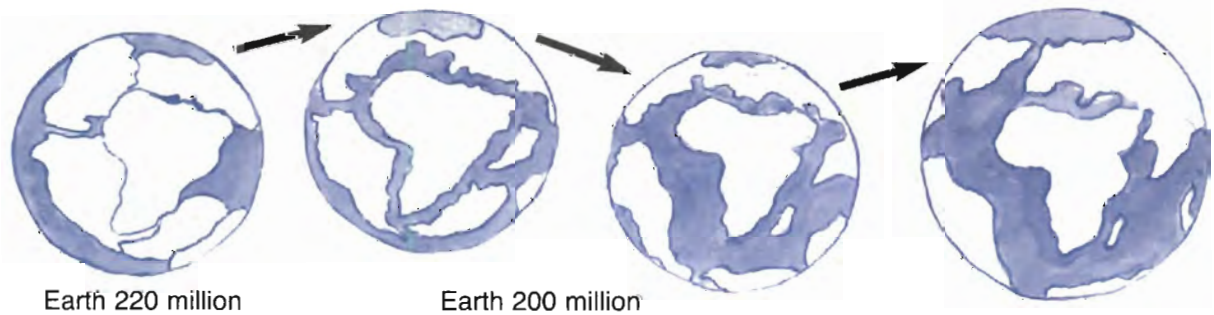
2. Big rock crystals, such as amethysts, grow slowly over long periods.
   Make a saturated solution of sugar or alum.
   Allow it to cool down and take out a tiny crystal.
   Tie a thread around your crystal and suspend it in the solution, in a still place, for three days.
   Don't let any other crystals grow on the thread.
   Wipe them off so that your main crystal can grow bigger.



The shape of things to come

The continent of Africa is part of a large floating crustal plate on the surface of the Earth's mantle. Currents within the mantle slowly drag the continents around the Earth. Look at a map of the world. The continents look as if they can fit together like pieces of a jigsaw puzzle. We know, by looking at fossil remains of animals found on different continents, that these separate continents were once joined together.

Scientists think that 220 million years ago, South America, Africa, India, Australia and Antarctica were all part of one super-continent called **Gondwanaland**. Since then, these continents have drifted apart. Careful measurement shows that Africa is moving away from South America at the rate of about two centimetres a year. This is about as fast as your nails grow! A world map of the very distant future may look very different from the world map we know today.



Earth 220 million years ago

Earth 200 million years ago

Earth as it is today

University of Cape Town

WHAT I HAVE LEARNT about the Earth's structure

Are these statements true, false or half-true?

1. The Earth's crust has no breaks in it.
2. The Earth's crust floats on a thick liquid.
3. Earthquakes are caused by movements in the crust.
4. All rocks on Earth are either igneous rocks or formed from igneous rocks.
5. The continents are slowly drifting apart.

Remember these new ideas

We have learnt many new words. Select the meaning from the list below and then add them to your natural science dictionary.

anticlinal fold	The super-continent thought to have existed in the south
Gondwanaland	The hot liquid rock in the mantle
igneous rocks	Rocks which form from the decomposition of igneous rocks
magma	The layer on which the crust floats
mantle	Rocks which form when molten magma solidifies
metamorphic rocks	An downward fold in the sedimentary crust
sedimentary rocks	An upward fold in the sedimentary crust
synclinal fold	Rocks that have been changed by reheating

University of Cape Town

WHAT I HAVE LEARNT about the tools of science

Even with the help of science, we cannot dig a hole to see down to the Earth's core. So how do scientists know about the inside of the Earth? Why do they think that the continents in the south once formed a large super-continent? Scientists look at the **evidence** available. In the case of the Earth's structure, scientists study the powerful vibrations produced by earthquakes to learn about the inside shape. The behaviour of vibrations in solids is understood, so scientists can **speculate** on what the Earth must look like inside by studying earthquake vibrations.

In the case of Gondwanaland, they have used other **observed evidence**. In this case, scientific knowledge is based on intelligent speculation, as no people lived here 400 million years ago. Scientists may disagree on how to use the available evidence. We say that scientific knowledge is **speculative**. This means that it may change if new evidence becomes available. All scientific theories must be supported by observed evidence.

3.1 WHERE FOOD COMES FROM

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Plant and maintain your own food garden until you can harvest your own food.
2. Use the information you have found out about preserving food to store food more successfully.

THE MAIN SPECIFIC OUTCOMES:

NS-SO3 Learning to investigate, apply knowledge and make decisions to solve problems in innovative ways.

LLC-SO4 Learning to gather information from a variety of resources.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Plant and maintain their own food gardens to a crop which is harvested.
2. Use the information about food storage to grow food more successfully.

Farai, the food hunter

Farai was lost and hungry. He held a weapon ready in one hand as he made his way cautiously through the thick African bush. So far the animals he had seen had also seen him and they had escaped before he could catch them.



Farai had not eaten since the morning before, and already the sun was setting. His hand searched his food bag - empty! Nothing left! His water was also finished. He knew he would have to find food and water soon. With a dry throat, he looked longingly at the plants around him.

One plant looked like the water-rich melon he knew so well, but how could he be sure that this plant was safe to eat?

'There must be an easier way to get food,' he reasoned with himself as darkness fell over the bush-veld. 'It is not good enough to depend on luck alone when you are hungry and thirsty.' Night was a time of danger. Bigger, more capable, hunters would even now be moving out of their daytime hiding places.

Farai sat still, listening. Some people who went hunting during the night were never seen again. But he was very hungry. Perhaps he could trap some small night animal without putting himself in danger.

Hungry and exhausted, he set his trap and climbed up a tree to wait for the morning.

In your groups, discuss the story:

- If you were Farai, what would you have done to find food?
- Why did Farai have to walk so far from home?
- Why did he take so little food along on the hunt?
- What mistake did he make while hunting for animals?
- Why didn't he eat the water-rich melons?
- How could he have ensured that he had enough food nearer home?

The endless search for food



There are plants that we can eat and plants that are poisonous. Plants that are full of food and plants that have little food to spare. Moist, fleshy plants and dry, tough plants.

Long ago, people had to investigate every possible food plant very carefully. Not all foods that are safe for animals can be safely eaten by human beings. Many people have become very ill and some have even died from eating unknown plants.

Not even all parts of every food plant are safe to eat. We eat the underground tubers of potatoes, but the leaves and berries of the potato plant are very poisonous. We eat the apples from an apple tree, but the stem and leaves of the apple tree are not edible. They are impossible to digest because they are hard and woody.

Other plants are so dangerous that we are taught never to eat them. Some mushrooms, like the death cup, kill over half the people who taste them!

Today we know of over 2 000 types of edible plants world-wide. Of these, only 150 types are used and only 20 types are common.

In your groups, discuss the following:

- Try to list the world's most common food plants.
- How many plant foods are found in your home?
- How many are grown in South Africa?
- Why are some foods so expensive?

At some stage, people discovered the value of planting seeds near their homes. So the food collectors became food farmers who could feed many more people with less effort and risk. People could live together in larger communities and devote time to many other things besides searching for food. In traditional communities in Africa, food plants are still grown mostly by women. In fact, women may have been the first farmers in this country long ago!



The death cup is a poisonous mushroom

University of Cape Town

EXPLORING SCIENCE GROW YOUR OWN FOOD

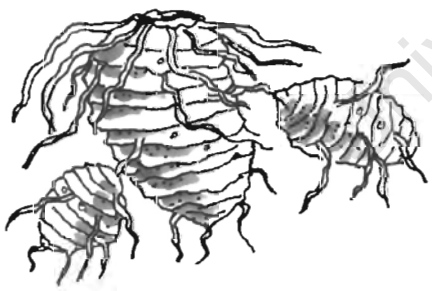
Before there were markets or shops, people had to grow their own food. It's easier to do this than most people realise. Many plants can be planted in pots or containers, in school grounds or your back garden. You don't need much space to grow food. But to be a successful gardener, there are a few basic rules.



Follow these steps to make a simple trench food garden:

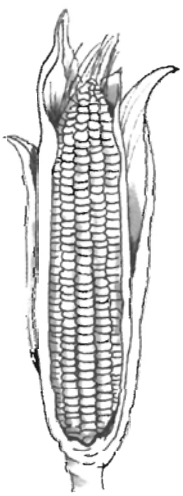
1. Find a small piece of ground that is level and sunny.
2. Dig a trench, the size of a door, to knee depth.
3. Half fill this trench with anything that comes from a plant (leaves, grass, newspaper, vegetable wastes).
4. Water your plot well, cover it with the soil and then water it again.
5. Cover the surface with grass clippings.
6. Plant vegetable seedlings in rows.
   Leave about 20 centimetres between small plants and 30 centimentres between bigger ones.
7. Water your plants every day. If necessary, pull out some plants if they are growing too close to each other.
8. Check that there are no insects eating your plants.
9. Protect your vegetables against the wind and strong sun with shade cloth or a light roof of sticks and grass. This will stop them withering and burning in the wind and sun.

HINT:
If you plant seeds, the plants will take six weeks longer to grow. Rather plant seedlings - they will grow into mature plants in one term!



Wild food: Amadumbe
(arum lily roots or potatoes)

Cultivated food:
Mealie



Challenge:
You will face many problems as you try to grow your own food. Your food plants will also be good food for many insects and their larvae! Ask people in your community how they stop the insects from eating their food. Share the solutions you found out with your class.

What vegetables to plant

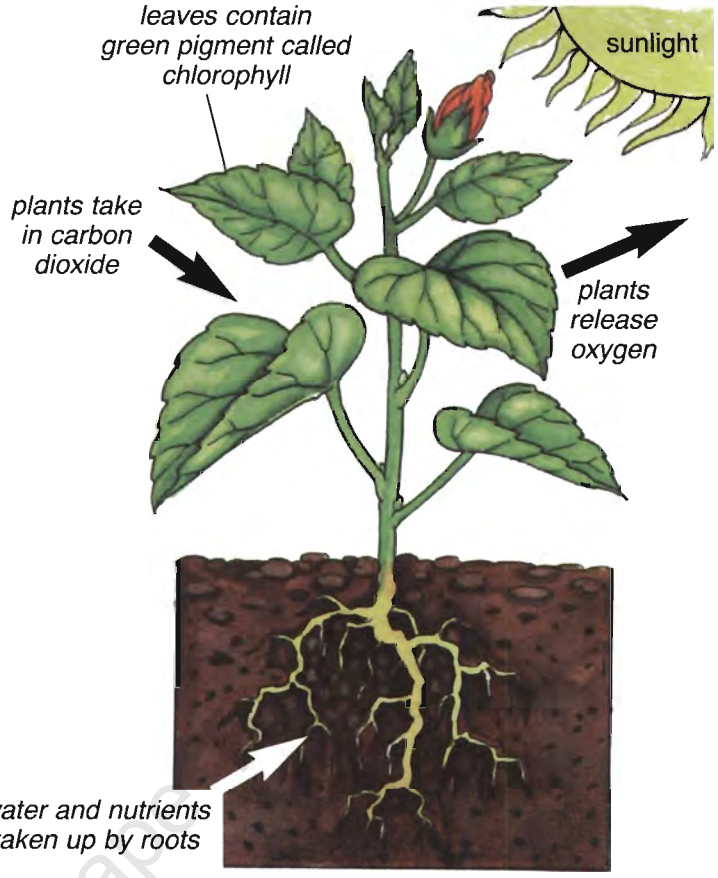
1st term: Peas, onions, potatoes, lettuce.
2nd term: Carrots, spinach, peas, lettuce.
3rd term: Turnips, Beetroot, potatoes.
4th term: Beans, pumpkins.
Any time: Tomatoes, cabbage.
Other plants to grow: Peppers, mealies, marrows, squashes.

University of Cape Town

Green - the colour of food making

Only green plants have the wonderful ability to make food out of the soil and atmosphere. Without green plants there would be no life on Earth!

Plant leaves contain a green pigment called **chlorophyll.** Chlorophyll uses sunlight energy to turn carbon dioxide (CO_2) from the air and water into an energy food called sugar. This process happens during the day time when the sun is shining. At the end of this process, plants release life-supporting oxygen (O_2) into the atmosphere. So green plants produce food and oxygen which together with water are vital to life. This process is called **photosynthesis** which means 'built up using light'.



Scientists explain the chemical process of photosynthesis like this:

Water + Carbon dioxide + **sunlight energy** = Sugar and **energy** + Oxygen

$6H_2O$ + $6CO_2$ = $C_6H_{12}O_6$ + $6O_2$

When we (or any animal) eat plant food, we get plant energy for our body's life processes.

© University of Cape

Without green plants we would all soon die

Do you think this statement is true?

Once the food is made in a leaf, it is quickly moved to a safer part of the plant where it can be stored or used to help the plant do its work.

Potatoes are safe underground food stores. Apples are exposed food stores that are meant to be found and eaten by animals that help to spread apple seeds far from the apple tree.



WHAT I HAVE LEARNT about food making

Are these statements true or false?

1. Water (H_2O), oxygen (O_2) and food are vital to all human beings.
2. Plants make a gas called carbon dioxide (CO_2) which we need for breathing.
3. Sugar is made in plant leaves.
4. Chlorophyll is able to capture energy from sunlight.
5. Water is a vital element in the process of food building.

EXPLORING SCIENCE WHERE PLANTS STORE FOOD

Using resources, find out where the plants listed below store their food.
Make a copy of this page.
Link the food label to the part of the plant it comes from in the picture.
Or you can draw the food onto the picture of the plant.



potatoes peas lentils

maize pineapple

cabbage

peanut pumpkin beetroot

caulifower carrot

peach sweet potato

sugar cane water melon

avocado pear wheat

bananas

Think about these questions:

- What advantage is there in storing food in so many different parts of a plant?
- Choose one of your favourite foods and tell your group how you like it prepared when you eat it.

University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

agriculture	Farming with plants
animal husbandry	The green substance in leaves that captures sunlight energy
chlorophyll	Farming with animals
naturalist	Building up food from light, carbon dioxide and water
photosynthesis	A person who studies nature

WHAT I HAVE LEARNT about early naturalists

In every culture there have always been men and women who have pioneered new studies. The study of plants and herbs for food and muti (medicine) is as old as humankind in Africa. Early scientists or naturalists observed the plant and animal life in their areas. They saw which plants animals used. They came to understand and value plants. With this increased knowledge, they had greater opportunities to help their communities and they became important people.

Their knowledge was passed on from one generation to the next. Much knowledge of science was also brought into this country from other cultures and has been useful, particularly in agriculture and animal husbandry, to promote the production of food for all communities in our country.

University of Cape Town

3.2 DANGER IN OUR FOOD?

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Understand food poisoning and know how to protect yourself from it.
2. Be more informed about how to store spare food.
3. Be able to investigate the effectiveness of some traditional methods of preserving food.

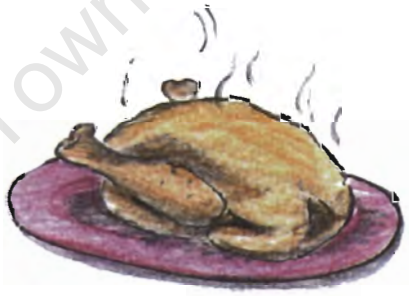
THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate the rate of food spoilage.
NS-SO2 Applying scientific knowledge to a specific situation.
NS-SO3 Using scientific principles to solve a problem.
NS-SO6 Understanding the relationship between science and culture.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Investigate the effectiveness of salt and sugar to control bacterial growth.
2. Demonstrate an understanding of the concept of the bacterial contamination of food.
3. Select scientific principles in solving the problem of contaminated food.
4. Demonstrate an understanding of how science is reflected in traditional methods of preserving food.

Dying... for a bite of chicken!



That Saturday was a very special family time - Grandma's eightieth birthday! The whole family would be celebrating. Everyone was bringing their favourite dish to share with the others. There were so many delicious things... salads, cooked potatoes, cold chicken, hot spicy chicken stew, cold polonies, hot vegetables, ice creams, jelly puddings and cool drinks for all. It was wonderful. We all ate till we could eat no more.



Grandma was so excited, she could hardly eat. She got so many presents that by the time she was ready to eat, there were only puddings and ice cream left. She didn't mind, as she wasn't that hungry.
The problems started on Sunday evening. The phones began to ring. Some of the family were getting ill. Nausea, vomiting, headaches and fevers with terrible stomach cramps and diarrhoea. Everyone was sure it was something they had eaten at the party. But what could it have been?

Which food do you think was the problem food?

Some of the children became so ill that their parents took them to doctors who said they had food poisoning. When specimen stools were examined under a microscope, the culprit was found... ***Salmonella enteritis bacteria***!



The pathologist said this bacteria grew quickly in under-cooked meat, especially chicken, eggs or fish. When cousin Susy died in hospital, the Department of Health sent a health inspector to investigate where the Salmonella bacteria had come from.
It was awful! Many members of our family were very sick in hospital having antibiotic treatments. We were all very worried.

But, strangely, some of us never got sick. That was a clue. How do you think the information in paragraph two about Grandma could help us?

University of Cape Town



The inspector asked each person to write down what they had eaten and especially which plate of chicken they had eaten from. But Cousin Arthur was a vegetarian, and he still got food poisoning. How could Salmonella have got into his salads? We wondered if any of our food was safe.

Finally, the inspector deduced that all those who had eaten Aunty Doreen's chicken and salads had got ill. I was surprised - they had looked and smelt good! The spicy, hot curried chicken looked much more dangerous to me, but the inspector said it was safe to eat. **Do you know why?**

Salmonella

You cannot see these tiny organisms without a microscope. These bacteria can grow quickly on moist, warm food between 20 and 50°C. They can double their numbers every 15 seconds!



Health at risk

- Where did the bacteria in the story come from?
- What safety rules were ignored at the abattoir and in Aunty Doreen's kitchen?
- What other work do health inspectors do?

Every year, millions of people get food poisoning because they ignore basic health rules, like washing their hands before preparing food.

The investigation shifted to Aunty Doreen's kitchen. She was too sick in hospital receiving antibiotic treatments to care. The inspector looked unhappy when he saw the wooden cutting board. He took it away for testing. We wondered why. Then he asked Uncle Phillip where the chickens came from. He went to the shop where they were sold. And then to the abattoir where they were slaughtered and packed.

In the end, we learnt the full story. A packer at the abattoir had packed chickens without wearing gloves. His hands were dirty - that's where the Salmonella had come from. Unluckily, Aunty Doreen picked one of those chickens. It was frozen, so she felt safe.

But on the way home, she stopped to chat to a friend and the chicken thawed out in the hot car. When she unpacked it, some watery juice dripped onto the salad she was making. That was how Cousin Arthur got ill!

The wooden board she had cut the chicken on was full of dried Salmonella spores. Every time she touched anything with her wet hands, she spread the bacteria around the kitchen. The heat from cooking the chicken killed the Salmonella, but when a cooked piece of chicken fell onto the infected table top, Aunty Doreen put it back on the plate.

On the way to Grandma's party, the Salmonella spread quickly in the warm car, infecting all the other chicken on the plate. Everyone who ate that chicken got very ill, and... poor Susy! What a terrible way to end a party!

University of Cape Town

How safe is our food?



In the past, people grew their own food. They knew where their food came from. They ate it fresh. Today our food can come from anywhere in the world and we don't know how careful other people were when they picked it, packed it and preserved it for us. You can buy foods with bacteria on them and not even know it. There is no such thing as risk-free food!



Salmonella is a common bacteria that causes food poisoning. It can grow on poultry meat - a favourite South African food. A single drop of juice from infected meat can give you food poisoning. Fortunately, bacteria can't move easily by themselves but stick easily on our food. Cooking food well, right to the middle of the meat, kills them. Cold temperatures (like those in fridges and freezers) stop them from growing, but doesn't kill them. Washing your hands before and after working with food flushes them away.



Food spices like garlic and onion kill all bacteria in foods. Thyme, cinnamon and chillies kill most bacteria in food. In the hottest countries such as India and Mexico, where bacteria grows on meat quickly, we find some of the hottest and spiciest recipes and fewer cases of food poisoning.

There are other ways of protecting food besides cooking, freezing and spicing.

How are these foods preserved? Match the foods in the left column with the scrambled answers in the right hand column:

FOOD	PRESERVED FOR SALE BY:
Fruit	Sugaring, cooking and packaging
Vegetables	Canning and fresh
Meat (including chicken)	Canning with sugar preservatives
Cheese and Butter	Drying, fresh, plastic wrapped, canning
Sweets	Preserving with chemicals and bottled
Jams	Freezing, cold plastic wrapping
Cool drinks	Drying, spicing and salting
Biscuits	Baking, drying, packaging
Biltong	Drying, powdering and salting
Cereals	Cooking and drying
Pastas (noodles)	Dried and box packaged
Soups	Plastic wrapping and chilling in a fridge

When people started producing more food, there was too much to eat at once. Food had to be stored safely or preserved. Modern methods (electricity and chemicals) were not available then. Electricity is still not available in all homes yet. Which of the food preserving methods listed above can anyone use anywhere?

University of Cape Town

EXPLORING SCIENCE BILTONG AND BOKKUMS!

Biltong is a traditional favourite food for many South Africans. To prevent bacteria growing on this uncooked meat (or fish), the factors that encourage their growth must be controlled. Bacteria need **moisture, warmth** and **food** to grow.
Drying food is a favourite method in the warmer, dry parts of our country.

- How could you stop a strip of meat or a fresh pilchard (fish) from rotting?
- How are biltong or bokkums made?
- How does each step prevent bacteria growing?
- How did people use these traditional foods long ago?



Investigation:
Bacteria love meat and warmth together, but if moisture can be removed by drying, they die. You can investigate the growth of bacteria.

You will need:
gelatine and minced meat which you will cook together, six sterilised lids (those from jam bottles will do), some rotten fish or meat.

1. Prepare a small amount of strong gelatine.
   Cook some with the minced meat to make a food medium on which bacteria will grow.

2. Number the lids or containers.
   Prepare each of the six containers as follows:
   In containers 1 and 2 - add the minced meat mixture, no salt;
   In container 3 - minced meat + 1 pinch of salt;
   In container 4 - minced meat + 2 pinches of salt;
   In container 5 - minced meat + 4 pinches of salt;
   In container 6 - minced meat + 8 pinches of salt.

Caution!
Take care not to touch the growth medium yourself - it could make you sick.

3. Stir each mixture and allow it to set firmly.

4. Take a piece of rotten meat or fish (which will be carrying bacteria) and touch the mixture in containers 3 to 6 with it.

5. Observe and take records of what happens to each container of mixture over a period of two weeks at room temperature.

6. Explain what has happened and why.

University of Cape Town

Some traditional methods of drying food



Before people had fridges to help them preserve food, they dried, salted or smoked fish and meat (e.g. biltong and bokkums). This food could be boiled and soaked later in fresh water to remove the salt.

Milk was shaken until the cream thickened to form curds. The curds are sometimes taken out and further grilled or smoked. A little curd added to the next batch of milk helped to start the fermentation process. Sour milk was traditionally preferred to fresh milk in Africa.



Fruits had sugar added to them while boiling. This made jams and stewed fruit. Many fruits were dried with or without sugar (mebos).

University of Cape Town

WHAT I HAVE LEARNT about food poisoning

Are these statements true or false?

1. Food poisoning results in minor discomfort.
2. Poisoned food always smells bad.
3. Food can be contaminated before you buy it.
4. There is not much you can do about food poisoning.
5. Food poisoning is always fatal.
6. Traditional food preservation methods are not as good as modern methods.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

abattoir	An instrument for examining very small organisms
bacteria	A place for slaughtering food animals
biltong	A very small microscopic organism that may cause disease
bokkums	A person who lives on a diet of plant food alone
curd	A salted, spiced strip of uncooked dry meat
diarrhoea	To have a running stomach
infected	A salted dried small fish
microscope	To be a carrier of disease bacteria
nausea	A product of separating milk
vegetarian	A sense of wanting to, but unable to, vomit up food

WHAT I HAVE LEARNT about health science

While the health of an individual is looked after by doctors of different kinds, health inspectors look after the health of communities. They try to stop diseases being spread through contaminated food. To do this, the health inspector has to have a good working knowledge of food science, the human body and the methods of scientific investigation. Health inspection is an applied Natural Science.

University of Cape Town

3.3 YOU ARE WHAT YOU EAT

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify why so many young children died in the village in the story.
2. Design your own solution to the problem of how to save the children.
3. Plan a diet for healthy eating.
4. Investigate your own ways of baking good bread.
5. Understand the dangers of 'fashion' foods.

THE MAIN SPECIFIC OUTCOME:

NS-SO3 Learning to solve problems and make decisions in cutural contexts.

PERFORMANCE INDICATORS OF THIS OUTCOME:

1. Identify the problem caused by an unbalanced diet and social taboos.
2. Debate issues around food and nutrition through discussion and research resources.
3. Design a balanced diet for healthy eating.
4. Learn through experimentation how to bake good bread.
5. Understand the dangers of 'fashion diets'.

Taboo milk and dying children



Some years ago in KwaZulu/Natal, a team of food experts found a village where one out of every four babies died before their first birthday. The babies had fat little bellies and they ate enough food - lots of putu porridge, mother's milk and black tea. But they sickened and died just the same. The experts thought the disease may have been ***Kwashiorkor!*** **(Find out what this sickness is before you read any further.)**

The team studied the food the people ate and found that some women never drank milk because their husbands were poor and did not own a cow or a milk goat. There were plenty of cows in the community, but a woman could only drink milk from her husband's own herd. It was strongly ***taboo*** for a woman to drink milk from another man's herd. The team knew that the mothers needed more protein food, but that they were poor people and the only rich protein there was taboo for many.

Discuss the following in your groups:

- How could the women get more protein in their diet?
- How would your solution help to save the dying children?

When the team realised what a strong hold the taboo had, they introduced powdered milk that did not belong to anyone else in the village. This milk was accepted by the community. Mothers began to drink it and the death rate in the children dropped to one in 10.

- What do you think was the reason for this taboo?
- Why was this taboo dangerous to the health of the babies?
- What are the reasons behind **your** food 'taboos'?

A Venda recipe for crunchy locusts

1. Collect a lot of locusts.
2. Pull off the locusts' legs and wings.
3. Gut and wash locusts.
4. Stir fry in garlic butter till their colour changes.
5. Add salt or peri peri.
6. Eat with putu porridge.



Would you use this recipe from the ***Saturday Star***? Locusts are full of protein and could help to solve the problem of hunger.

University of Cape Town

Taboo foods?

What would you definitely not eat tonight... or ever!

Locusts Snails

People Pork Alcohol

Horsemeat Cat or dog meat

Eggs Heart meat Owl meat

Fish Snake meat

Pig's trotters

- Which of these foods would you eat and why won't you eat the others?
- Is this choice a social or cultural taboo or is it a personal choice of yours?



EXPLORING SCIENCE KNOW WHAT YOU ARE EATING

Whatever you eat becomes part of your body within a few hours!
Food can change your body health and shape. By law, producers of processed foods have to show what nutrients the food contains by printing this information on the wrapper or label.

1. Study a wrapper from a processed food tin or packet. Look at the list of ingredients.
   Then:
   - Find out what proteins, carbohydrates and fats are used for in your body.
   - Why is fibre so important?
   - Would the processed food you studied help the people in the village in the story to solve their problem?
     Why?
   - What are vitamins and minerals?
   - Why is flavouring and colouring added to the processed food?

2. Bring wrappers or labels from your favourite food to school.
   In your groups:
   - Compare the food values of your different foods for energy, growth /repair and controlling body processes.
   - Discuss what a healthy diet would consist of.

INGREDIENTS:
Wheat, sugar, salt, malt, fat, colouring, vitamins A and C.

NUTRITIONAL INFORMATION:
(per serving of 30g)

Energy	395 kJ
Protein	4,4g
Carbohydrate	22,1g
Fat	1,0g
Sodium	240mg
Potassium	245mg
Cholestrol	0mg

University of Cape Town

Bread - the staff of life

Did you bring bread sandwiches to school today? Did you know that bread was first baked in Egypt and is an African discovery? Most South Africans eat a lot of bread or putu (mealie meal porridge) every day. There are many different types of bread. Can you name a few of these bread products from a bakery?



Bread is a symbol of life to many people. The Koran calls it the 'staff of life'. Jesus is called the 'Bread of Life' in the Bible. Bread is part of the communion and mass reminding Christians of the body of Jesus.
Hot cross buns are reminders of the death of Jesus.
Matzos (bread baked without yeast) reminds Jews of Passover Night when the Israelites had to leave Egypt.



People have been baking bread every day for the last 6 000 years! Many people used to think that white bread was better than brown bread. White bread costs more to make, so it was considered to be the food of the rich.

- What is the difference between wholewheat, brown and white bread?
- Which bread do you think is more healthy? Why?

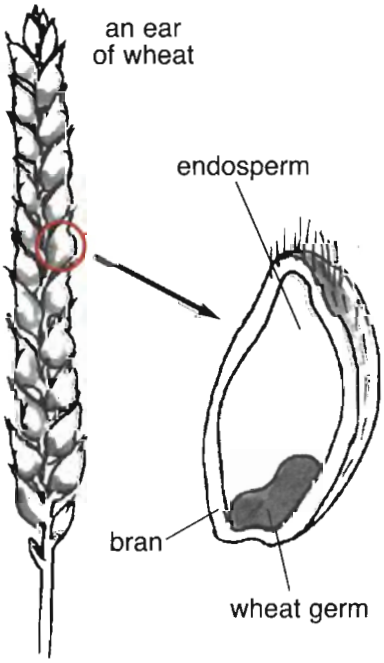


University of Cape Town

Wheat - the grain of life

What happens to the different parts of the wheat seed when it is used to make bread?

Part	Description	Food value
BRAN	Outer seed coat	Fibres, Vitamin B and minerals
GERM	Plant seed	Fats, proteins, Vitamin B and E, Iron
ENDO SPERM	Seed food	Carbohydrates and proteins



- How does this table help you see what type of bread has all the nutrients present in wheat?

EXPLORING SCIENCE MAKING YOUR OWN BREAD

Most people agree that the best bread is soft and spongy inside, has a crisp brown crust, is easy to eat, lasts well and tastes good!



In your groups:
Design your own bread recipe by mixing bread flour, wheat seeds, butter, yeast, water, food colouring, salt and sugar together to make different kinds of bread.

1. Keep a record of the ingredients you used and how much you used of each.

2. Record the method you used to mix the bread.

3. Note how long and at what temperature you baked your bread. When your bread is baked, share it with the other groups. Discuss what is the best way to make bread.

WHAT I HAVE LEARNT about food

1. A healthy meal contains a balance of ... (6 answers).
2. Fibre foods are important because ...
3. _____ is a protein deficiency disease.
4. People eat different foods because...
5. We knead dough because...

Food fads and fashions

Many cultures equate being slim with being healthy, but this can be misleading. Excessive dieting can be dangerous and unhealthy! Bad diets can kill us as surely as starvation does. It's the same process of the body wasting away from not getting the nutrients it needs. Discuss nutrition and unbalanced diets in your group.

Any food (protein, carbohydrates or fats), eaten in excess of body needs, can make you fat. All food makes fat if we eat too much of it. Junk foods, like fizzy cool drinks, potato chips and sweets, contain only sugars and starches. These foods do not contain a balance of food nutrients, despite their huge popularity. We cannot survive on a diet of these foods alone. Most of us eat too much fat (fried food) and sugar carbohydrates and too little fibrous carbohydrates (cereals), vegetables and fruit.

Jack Sprat could eat no fat,
His wife could eat no lean.
But just the same they both got fat;
Strange as this may seem.

(Cameron, 1971)

Is this rhyme true?
Discuss this in your groups.

University of Cape Town

Getting too thin

Being too thin can be even more dangerous than being too fat... it can kill faster. Some people may suffer from eating disorders and believe that they are too fat even when they are thin. They starve their bodies of foods to life-threatening levels. They may choose to eat less at first, but soon cannot help themselves. They may lose the ability to digest food... and die.

A normal and healthy body reflects a healthy state of mind. How 'normal' are you?

Average weights

Age	Height
11-14 years	157 cm
Boys	**Girls**
45 kg	46 kg

Very few of us are ever on the average, but are still normal. Five kilograms above or below this average weight is perfectly normal. If you are shorter, then less weight is normal for you. If you are taller, more weight may be perfectly normal for you.

People believe they can lose weight by:

Eating less
Eating more fibres
Drinking more water
Eating no carbohydrates
Not mixing food types
Eating more fruit
Chewing garlic or onions
Using sugar pills
Using appetite suppressing pills
Playing more sport
Jogging daily
Joining a gym
Doing aerobic exercises
Living a less stressful life
Cutting out junk foods
Sleeping more and eating less
Eating vegetarian food
Eating health foods
Eating only at the table
Joining a diet watching club
Getting a 'fat off' prescription

What do **you** think?

University of Cape Town

WHAT I HAVE LEARNT about diet and health

Match the answers in the right hand column to the sentences on the left:

1. Body shapes are...
2. The only way to lose weight permanently is to...
3. Junk foods are called this because...
4. It is dangerous to crash diet to please other people because... (two answers)

- a way to make friends.
- only cultural fashions.
- an unhealthy diet can make you become very ill.
- eat healthily and moderately and exercise a bit.
- diet and keep running.
- they do not have all the major food groups required by the body.
- this is not the way to win approval.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary

kwashiorkor	Seed food or flour
proteins	The tiny seed plant before it germinates
carbohydrates	The seed coat or husk of wheat
fats	A strong belief preventing people from doing something
vitamins	Nutrients that control body processes
minerals	Vital elements needed in the body
taboo	Nutrients stored in the body for release of energy
bran	High energy sugar and starch foods
wheat germ	Nutrients that build up body tissues
endosperm	A protein deficiency disease

WHAT I HAVE LEARNT about science and cultural taboos

It is not enough to understand good science. The milk taboo problem in the story could only be solved when the food scientists understood the social behaviour and cultural customs of the people concerned. No matter how right the scientists were in identifying the disease and the need for more protein in the women's diets, the cultural belief, or common sense, of the people was stronger!

The taboo belief was only broken when powdered milk was bought in from outside the village. Then the women could accept milk without any obligation to another man in their tribe. Any health scientist must recognise and respect the power of the cultural beliefs of the people or the science will not be accepted.

University of Cape Town

3.4 THE HUNGRY PEOPLE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify a better solution to the problem of coping with hunger in southern Africa.
2. Understand the local effect of the unequal sharing of world food resources for hungry people.
3. Plan a diet for one day for a family based on limited money and their energy needs.

THE MAIN SPECIFIC OUTCOMES:

NS-SO5 Using scientific knowledge and investigation to support responsible decision-making.
NS-SO8 Understanding ethical issues, bias and inequalities related to Natural Science.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Interpret alternative strategies for coping with food shortages.
2. Acknowledge a variety of viewpoints and explore their bias through debate.
3. Identify the reasons, scientific and otherwise, for decision-making, based on information sources.

Food riots in Harare



In January 1998, Harare, the capital of Zimbabwe, experienced...

- a 20% rise in the price of maize meal, and other basic foodstuffs;
- a price increase attributed to the devaluation of the Zimbabwe dollar and increased government taxes;
- citizens democratically protesting against food price increases;
- citizens expecting the government to control food prices and provide cheaper food;
- a negotiation failure, leading to a state of food crisis;
- three successive days of rioting and looting;
- a need to reassert the rule of law and order;
- shops being looted, burned and stoned by angry crowds;
- the army attacking unarmed civilians;
- three shop looters shot by soldiers in the city streets;
- rioting which is bad for any country needing to borrow money to create jobs for its people;
- a government bill reversing this price increase;
- criticism of the government for using 40 000 soldiers, live ammunition and tanks to restore order.

From various African news media.

Could these riots have been avoided?

Look at the list of suggestions in the block on the right and decide in your group:

- What was the real problem?
- What were the causes of the riot?
- If your solutions were carried through, would the food riot have been prevented?

Avoid food riots by...

- Increasing food prices slowly
- Subsidising the rising costs
- Producing food more cheaply
- Planting more food crops
- Educating people about the food crisis
- Not using the army against civilians
- Arresting looters and thieves
- Encouraging less eating
- Promoting smaller families
- Selling alternative foods
- Planning for drought conditions
- Replacing cash crops (like tobacco) with food crops

Do you have any solutions of your own?

University of Cape Town

Living hungry in the world village

If the whole world was a single village with 100 hectares (a hectare = 10 000 square metres) of farm land, containing 100 people and all their yearly wealth was R100, then in this village there is enough food to feed everyone if it is shared...

BUT...

- **Six villagers own and live on 50 hectares of land.**
  They have R50 between them (about R8,30 each). Their children have enough to eat and are healthy. They are powerful and wealthy enough to buy whatever they want. They feed their excess food to their cattle. (This food could feed 18 other hungry villagers who do not get enough food and are sick as a result of hunger.) The rich villagers say they want more meat in their diet and they can afford it. When these villagers do help the other hungry villagers there is always a high cost to be paid for the help.

- **94 villagers share the other 50 hectares of land.**
  - 18 of these villagers have enough land to eat well. They share R24 a year (about R1,30 each). Their children do not go hungry.
  - 76 villagers are very poor and have to share R26 (about 34 cents each) and have very little land. 50 of them will be hungry all the time.
  - 8 of these hungry villagers are Africans.
    - 4 of these hungry Africans are malnourished. They are weak and sick. Because of this they cannot work and the rich villagers think they are just lazy. These villagers have many children because children in their homes die so easily from lack of food.
    - 1 villager (an African child) is dying slowly of starvation.

Discuss this village's problems in your group.

- What can be done?
- Why doesn't this happen?

(Each villager represents 60 million people and each rand represents R20 000 in the real world.)

Hungry to bed

Across the world, over 200 million children go to bed hungry every night.
They may never experience a full belly! Most of these children are Africans.

This is a hungry three-year-old's daily diet:

Breakfast:
1 slice brown bread with margarine
1 cup of tea (with 1/2 teaspoon of sugar and milk powder).

Lunch:
1 cup of tea (1/2 teaspoon of sugar and milk powder).

Supper:
1 cup of tea (1/2 teaspoon of sugar and milk powder) and dry bread.

What do you think is wrong with this diet?

Hunger & wars

Did you know that hunger kills more people every year than all the wars in the last 150 years put together?

Eleven million children die from the lack of food each year. That is about 30 000 children a day or **1 child every 3 seconds!**

University of Cape Town

The hungry Africans



In Africa, the population is increasing faster than the food supply. Most hungry people come from areas where they cannot grow their own food because they have no land of their own; or no water to irrigate their land; or not enough money to buy food from others.
They are desperate, and may be forced to take any action they can, or watch their children die from lack of food!

Political unrest and war drives many people off their land. Their crops fail, so they have no food. Droughts, floods and insect pests (locusts) have also caused crop failures in Africa. The result is always the same: food becomes scarce, people become weak, sicken and die of severe malnutrition and infections.

- In your groups discuss how a situation like this could affect: children, old people, women and refugees.

University of Cape

EXPLORING SCIENCE THE RISING COST OF FOOD

Make a list of 15 foods you find at home.
List what they cost now and then try to find out what these foods cost a year ago.

- Which food is cheapest and which is most expensive?
- Why are some foods so costly?

Plan a food budget

Divide up into four groups.
Imagine you have got a job and that you can use half of one of these four amounts - R15; R30; R50; R70 - to spend on food for your family.

Plan a food budget for a family of four people for one day.
Visit a shop and list what food you will be able to buy with your imaginary money. Try to buy food that is healthy.

- What is the the best way to solve the problem of how to feed your family? Share your findings with the rest of the class.

Use the data below to ensure that your family gets at least a total of 26 000 kilojoules of energy a day.

For example:

Breakfast:	Mealie meal porridge with milk
Lunch:	Oranges, cheese sandwiches, coffee
Supper:	Meat, potatoes and peas, milk

Food is energy of life. Food energy is measured in a unit called a **joule**. The minimum kilojoules needed for an adult is about 6 500 kJ per day, provided no heavy work is done. In the example above, the family would average about 6 732 kJ per day each. If they are an active family, this will not be enough food and they will feel hungry. On this diet, they will slowly lose weight. They will become tired and weak and unable to work properly. The family may slowly starve despite the fact that all the important food types are present in this meal.

FOOD VALUES

1 portion of ...	Energy values
Meal (2 1/2 Tbsp)	270 kJ
Pasta (1/2 cup)	270 kJ
Bread (1 slice)	270 kJ
Rice (1/2 cup)	270 kJ
Orange (1 small)	160 kJ
Butter (teaspoon)	180 kJ
Meat (1 slice)	236 kJ
Eggs (1)	236 kJ
Milk (1 cup)	600 kJ
Pumpkin (1/2 cup)	144 kJ
Potatoes (1/2 cup)	270 kJ
Cheese (1 Tbsp)	180 kJ
Mealies (1 ear)	540 kJ
Peas (1/2 cup)	270 kJ
Chicken (1 slice)	236 kJ

Example	Energy
12 meal porridge	3 240 kJ
8 milk	4 800 kJ
4 oranges	640 kJ
16 cheese	2 880 kJ
16 butter	2 880 kJ
16 bread slices	4 320 kJ
16 meat	3 776 kJ
8 potatoes	2 160 kJ
4 peas	1 080 kJ
8 pumpkin	1 152 kJ
	= **26 928 kJ**

or 6 732 kJ per person

University of Cape Town

The hungry families

Hungry families cannot afford expensive food. Many South Africans, particularly in the rural areas, have diets that lack enough energy (kilojoules) or are low on proteins and vitamins. These families will catch infections easily and their children may be sickly. Four out of 10 children in South Africa are always hungry!

- In your groups discuss what can be done for these hungry people. How could we solve this problem?

No protein

A survey of three Eastern Cape villages showed that 60% of families never ate meat, milk, eggs and fish (protein). Their food consisted mostly of starch (carbohydrates) - mealie meal porridge, samp, bread and tea.

The right to eat

The South African constitution's Bill of Rights says that everyone, especially children, has the right to food and to be protected against neglect. But in many homes these basic rights are not met due to the extreme poverty people live in.

- In your groups, discuss possible solutions to the problem of poverty and hunger.



WHAT I HAVE LEARNT about the hungry

Match these voices with the link statements in the right hand column below.

Voices of the hungry poor:

1. *'I am always hungry...*
   I have never been full.'

2. *'I look for work every day but I can't get it.*
   I can only eat when I get work...
   maybe twice a week.'

3. *'Sometimes I can't even look for work,*
   I'm too hungry to walk to town.'

4. *'I'm ashamed to beg for myself so I tell them*
   I have no food to give to my children.'

5. *'I don't have strength to work all day.*
   I'm old now but I still need food.'

6. *'Our lives are hard, we barely survive.*
   If food prices go up, we will starve.'

7. *'When I have no money I have nowhere*
   to stay. Sometimes I only have water
   to drink for days.'

Hunger links:

A. People on low kilojoule diets of less than 6500 kJ are weak and unable to work effectively.

B. 3 000 million people on Earth live with hunger every day.

C. People who live in poverty cannot buy food when prices increase.

D. Unemployment is a cause of poverty. Poverty leads to hunger.

E. Old people, who no longer have children to support them, are at risk of malnutrition.

F. 11 million children die of hunger each year. They are at risk in communities where food is scarce.

G. Food is only one of several basic necessities that the poor lack.

University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

joules

malnutrition

marasmus

A lack of protein and fat in the diet causing muscles to waste away and makes the body look like a bag of bones

A unit of (food) energy. A joule of energy can raise the temperature of 12,5g of water by 1°C. One gram of sugar supplies 16 joules of energy which would raise the temperature of 12,5g of water by 16°C

Literally, bad eating. A diet lacking essential food nutrients

UBUNTU AND HUNGER

Ubuntu is an attitude of caring and respect for others. Ubuntu is about understanding and giving. It is about people meeting other people's needs out of concern for them. To know of need and to ignore it is to be without ubuntu. Ubuntu means finding your humanity through sharing your life with other people. To have ubuntu is to be fully human. Assisting the needy and helping them to build a better life for themselves improves the quality of all of our lives as well.

Ubuntu is not charity - it means doing our duty to our fellow man. The challenge of Africa today is to live within the spirit of ubuntu - to help stop hunger by sharing resources with compassion and sensitivity, and to accept with dignity.

University of Cape Town

4.1 OUR STAR'S ENERGY

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain why the Sun is important in maintaining all life on Earth.
2. Choose the best surface for the transfer of solar energy in a solar water heater.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Applying scientific knowledge and skills to problems in an innovative way.

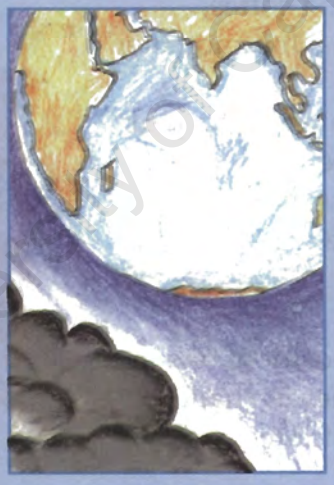
PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Demonstrate an understanding of the central role of solar energy in maintaining life.
2. Choose the optimum surface for the collection of solar energy.

The Black Cloud

Imagine what would happen if a huge, very dense, cloud of gas moved into our solar system from the darkness of space and cut us off from the light of the Sun. Fred Hoyle, the Cambridge astronomer, gave this some thought. Here he describes what *could* happen...

'The blackness started from midday. The sun set for the last time. It would never rise again. Imagine a dawn without the rising Sun! Everything became pitch black... not a single star in the sky. The light of our world gone out!



The endless night sky clouded over with heavy storm clouds. Cities ablaze with lights. Terrified sheep and cattle lowed in the dark countryside. Scared people huddling around fires and TV sets for news.

After three days the rain began to fall. Temperatures dropped steadily all over the world. Eventually rivers of dark raging water spilled over their banks, flooding farms and villages. Whole cities began to flood. Homes collapsed in mud flows. Inland seas formed on the plains. Torrents of rock and mud ran down from the mountains.

Hurricane force storms developed as the oceans cooled. Buildings crumbled, power stations failed and roads broke up as the storms tore first into the coastal cities and then inland. The storms raged on until there was no more food left. Animals and plants alike were destroyed, leaving only the terrible wet, cold darkness.

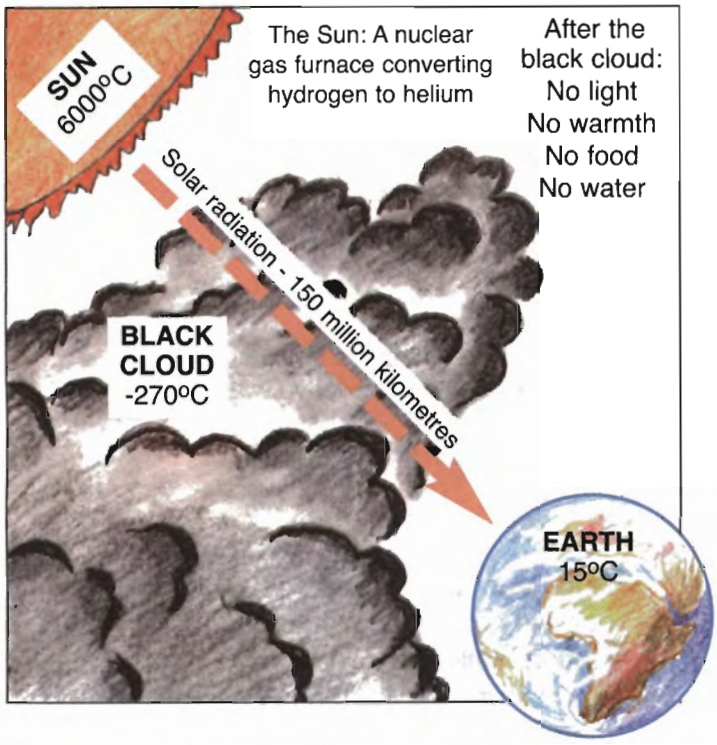
Then it grew very cold. The rain changed to ice and fell to the earth as snow and hail. Dams and lakes froze over. Taps froze up. Drifts of ice floes piled up high on the beaches. Hills and mountains of ice formed all over. The Earth was held in the grip of the last great winter.

And then the rain stopped. The world was silent except for the roar of avalanches. The last survivors burnt what they could for warmth and to melt ice for water to drink. Soon even they would not hold out against the cold.

In time, the seas froze over, killing the fish. The temperatures dropped to -270°C. This was the coldness of outer space. The once beautiful green Earth had become an ice world, but no one was left to see it...'

This is what could happen to our world without the Sun.

Based on *The Black Cloud*, F. Hoyle, Penguin 1957.



In your groups, answer the following questions about the story of a world without the Sun:

- What do we get from the Sun which the big cloud blocked?
- What would happen to plants if there was no sunlight?
- Why did it rain so much?
- Why did it become so cold?
- Why is it colder in winter than in summer?

EXPLORING SCIENCE HEAT ENERGY FROM OUR SUN

You will need:

water, black ink or powdered coffee,
two identical glass jars and a thermometer.

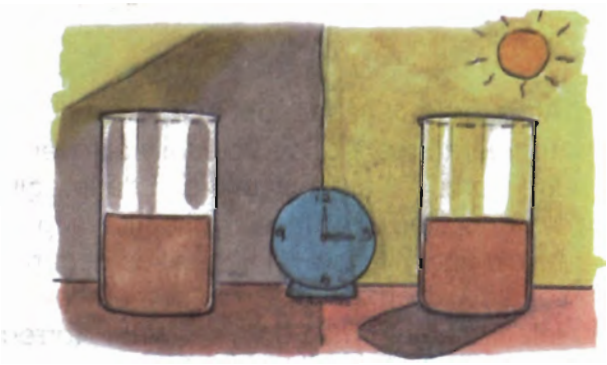


1. Half-fill the containers with water and colour the water with the dye or coffee.

2. Measure the temperature of the water in both jars and write it down.

3. Place both jars in a wind-free position, one in the direct sunshine and the other in shade. Leave both containers for 15 minutes.

4. Stir the water and measure the temperature of the water in both jars again. Write it down.



- What happened?
- How do we normally heat water?
- Compare the starting and final temperatures of the water in each jar.
- Explain any differences that there might be in the temperatures.
- What effect did sunlight have on the water in the jar which was placed in direct sunlight?

University of Cape Town

Energy from the Sun



When we stand in the sunshine we feel that we are being warmed. This heat energy from the Sun has travelled across space and through our atmosphere to warm us. We call this kind of energy **radiant energy**.

When we stand near a fire we can also feel heat on our skin. This energy is also radiant energy. All warm bodies give off radiant energy. Radiant energy is produced by the particles of the warm object vibrating backwards and forwards very quickly.

The surface temperature of the Sun is 6 000°C. This is as hot as a welding torch! We are warmed by the Sun, not because the Sun is very hot (for it is far away), but because it is very large (it contains 99% of the mass of the our system). As a result, it gives off huge amounts of energy. Only about one thousand millionth of the energy produced by the Sun reaches Earth. The Sun's radiant energy is called **solar energy**.



When you look at a rainbow you can see light of different colours. When light shines on raindrops at a certain angle, white light separates into different colours (red, orange, yellow, green, blue and violet). Visible light is only a small part of the full range of solar energy.

The different parts of the solar spectrum have different effects on different material.
The green parts of plants can capture and use any colour of light, except green, to produce plant foods (sugar and starches) in the process of photosynthesis (food making).
All life on Earth depends on the solar energy trapped by green plants.

University of Cape Town

Radiant energy consists of:

Gamma Rays destroy living cells. We use them to kill cancer cells.
X-Rays pass through living tissues. We use them to view the living skeleton.
Ultraviolet light penetrates skin causing sunburn and skin cancers. We can prevent this with UV sun screens.
Infra-red light is heat. It warms up objects. We use ultra sound micro-waves in ovens and to beam messages in telephone and radio communications.
Radio waves are used to carry messages through radio, cellphones and television broadcasts.

WHAT I HAVE LEARNT about radiant energy

1. In your groups, discuss the meaning of the word 'energy'.

Are these statements true or false?

2. Energy which can cross space is called radiant energy.
3. Radiant energy from the sun is called solar energy.
4. Solar energy consists of sunlight only.

EXPLORING SCIENCE HEATING WATER

You will need: four identical glass jars,
white paint, shiny black paint,
some black cloth, water
and a thermometer.



1. Paint one jar white and another jar shiny black.
2. Glue the black cloth over the outside of the third jar.
3. Leave the fourth jar transparent.
4. Half-fill all four jars with water.
5. Copy this table into your workbook:

Heat absorbing surfaces:	**Initial temperature of water in all jars: ____°C**					
Surface of container	After 5	10	15	20	25	20 minutes
Transparent						
White, shiny						
Black, shiny						
Black, rough						

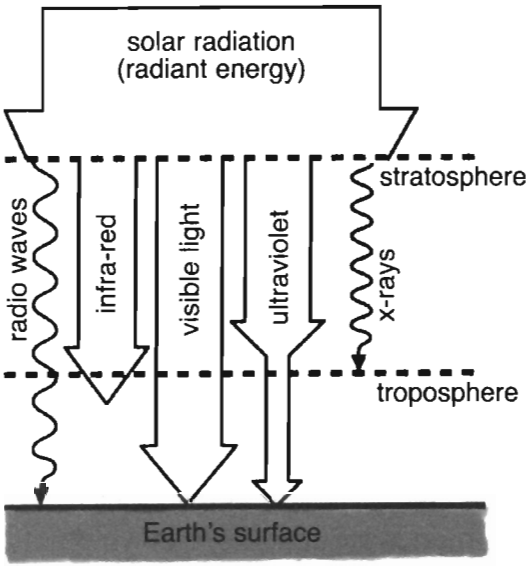
6. Measure the temperature of the water in one jar. Record the value in the table.
7. Place the four jars in warm, bright sunlight. Record the temperature of the water in each jar every five minutes for 30 minutes.
   Stir the water with the thermometer each time before taking the reading.

- What happened?
- In which jar was the temperature change the highest? The lowest?
- How do these two jar surfaces differ from each other?
- How does the temperature change in the two black jars compare?
- On a hot day, the black tarred surface of a road is much hotter than the white line or the lighter cement pavement edge. Why?
- What is the best colour to paint your house to keep it cool?

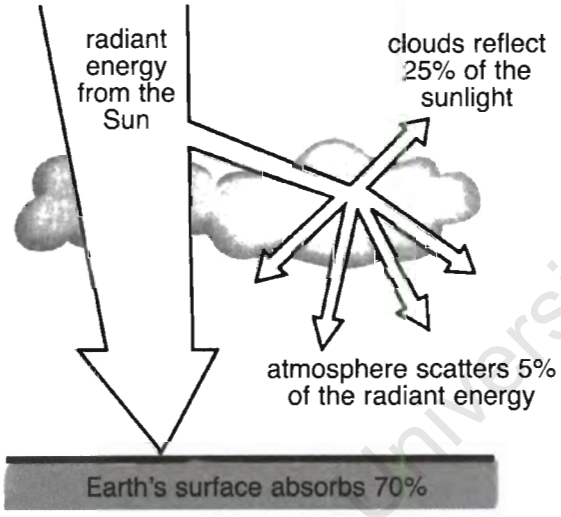
University of Cape Town

Solar heat and light

The Sun produces vast amounts of radiant energy but very little of this energy reaches the Earth. Our atmosphere reflects, scatters and absorbs a lot of this radiation. Some is reflected off dust and clouds. Most of the harmful x-rays and ultraviolet light are absorbed by the Earth's atmosphere. The rest of the radiant energy reaches Earth's surface.



The amount of radiant energy which reaches the surface of Earth depends upon the time of day, how much of the sky is covered by clouds and the season of the year.
In South Africa, the amount of energy absorbed by the surface varies between 700 watts per square metre and 1 000 watts per square metre at midday.



Radiant energy from the Sun warms the Earth. Sunlight also lights up the surface of Earth. This visible light makes it possible to see different colours. Some light falling on any surface is reflected and some is absorbed.

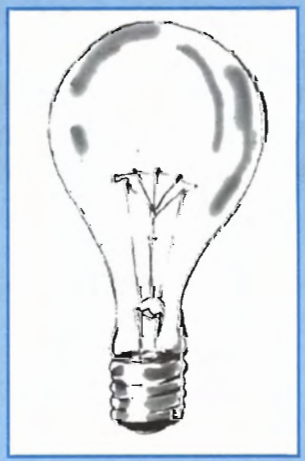
The light which is absorbed heats up the surface. The light which is reflected on a surface makes it a bright colour.
The nature of the surface of any object is important in determining how much of the light is absorbed and how much heat the object is going to gain.

What is a watt?

We measure the amount of energy which we use in a second in a unit known as a watt.

An ordinary household electrical bulb will produce 100 watts of heat and light energy every second.

An electrical kettle uses about 1 000 watts per second to boil water.



University of Cape Town

WHAT I HAVE LEARNT about solar energy

1. The amount of solar energy which reaches the Earth's surface depends upon the atmosphere, the time of day, the time of year and the distance that the energy travelled through the atmosphere.
   In your groups discuss why these factors have any influence on the amount of radiant energy reaching the Earth's surface.

2. You wish to heat water using solar energy. Should the surface of your collector be:
   - small and transparent
   - large and rough black
   - large and shiny
   - small and white
   - large and shiny black?

   In your groups, discuss which of the above surfaces will be the best solar heat energy collector.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

radiant energy	Energy which can travel through empty space
solar energy	A unit which measures how rapidly energy is being used or received
watt	Radiant energy from the Sun

WHAT I HAVE LEARNT about the tools of science

Scientists are interested in discovering how nature works. During their investigations, they often discover new facts about nature. Engineers use these facts, discovered by scientists, to make equipment that makes life easier for us. The use of science to solve everyday problems is called **technology**.

For example, scientists have discovered that large, rough black surfaces are best for converting radiant energy into heat. Engineers used these facts to build solar heaters which are used to heat water using sunlight alone. This invention saves many South African homeowners money that they would have had to spend on electrical energy to warm water for use in their homes.

University of Cape Town

4.2 SOLAR ENERGY

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify and describe some direct and indirect uses of solar energy.
2. Describe the difficulties associated with the use of solar energy.
3. Design a simple solar energy concentrator to cook food or boil water.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Applying scientific knowledge and skills to problems in an innovative way.
T-SO1 Applying the technological process to a design problem.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Describe the central role of the Sun for life on Earth.
2. Explain the role of the Sun in the water cycle and in the formation of wind and ocean currents.
3. Identify the practical uses of solar energy in their community.
4. Explain the difficulties associated with the use of solar energy.
5. Design a solar energy concentrator to cook food or boil water.

Survive the wild surf and thirsty beach



What a wild night! We battled against head winds that ripped the sails away. Huge swells pounded our small boat. At dawn we found ourselves close to the shore. It looked dangerous. The wild seas roared and burst over the rocks at the base of the cliffs between small sandy beaches. Without power in the boat, we were at the mercy of the wind and sea. We were drifting closer and closer to disaster. We steered towards the beach.

The boat shuddered. Our worst fears were realised as we hit a sand bar. The sea was swinging us towards the shore. The old boat was sturdy, but it began to lean sideways, shipping water. The shore looked uninviting, but it was our only hope. There was still time left before the boat broke up. The current was running parallel to the shore and taking us with it. Could we reach that tiny open beach between the headlands?

What could we take with us? We would have to swim to the shore and could carry very little. George packed a few tins of food into a haversack. I was worried about water. We had some on board, but the desolate coast could be waterless. Luckily, we had sent an SOS message off in time, but it might take our rescuers days to reach us. Even with all this salty sea water around us, we could still die of thirst, even if we reached the beach. Time was running out. The boat filled up with water...

You can make fresh water from salt water by evaporation and condensation. But we would need heat energy for that. There might be no dry wood on that desolate shore. But if the sun shone for a long time each day, we would be able to use solar heat energy to evaporate the sea water. For that, we would need a black plastic bag to collect heat energy with and something to collect fresh water in. A plastic bottle was a good start...

In your groups, discuss the following:

- How does water evaporate?
- How can a black bag be used to collect solar heat energy?
- How can you use a bag and bottle to help prepare drinking water from sea water?
- Make a drawing of the apparatus you would use.

University of Cape Town

Solar energy

Energy is essential for life.
The Sun is our main source of energy. Solar energy (energy from the Sun) is absorbed by gases in the atmosphere and warms the air around us. The heating of Earth's atmoshere makes plant and animal life possible.

The Sun warms the air unevenly. When the air is warmed it moves and becomes the wind that blows. Wind moves the surface water over the oceans and contributes to the ocean currents.

Solar energy dries our washing. On windy days washing dries even faster! Moving air (wind) turns windmills which are used to grind grain and pump up underground water for our use. Some special windmills can even generate electricity.



How are these activities linked to solar energy?

Solar energy is also used to dry fruit and vegetables, fish (bokkums) and meat (biltong). Drying is a useful way to preserve food. We can also use solar energy to evaporate the water from sea water so that we separate the water and the salt. We can also use an oven powered by solar energy to cook food.

University of Cape Town



Solar energy also causes changes in the weather. Did you know that the Sun helps to cause rain to fall?

As the Sun heats the ocean and dams, the water warms up and **evaporates** as water vapour. High up in the atmosphere, this water vapour cools and **condenses**, forming water droplets which fall back to the Earth as rain or snow. This rain helps our crops to grow and keeps our dams full and rivers flowing. This important natural process is called **the Water Cycle**. Often the rain that falls inland started its journey thousands of kilometres away in the ocean before it was evaporated by the Sun.

WHAT I HAVE LEARNT about the use of solar energy

In your groups, prepare a short illustrated report on how your community uses solar energy. Think about how each use of energy is linked to the Sun's energy.
Think about fuel for cooking (wood, coal, dung), growing and tending crops, drying washing and food, using moving air and water, warming homes and sending messages.

EXPLORING SCIENCE TURNING SALT WATER INTO FRESH WATER

Fresh water is scarce in many parts of South Africa. People who live near the sea could still have fresh water by heating salty sea water and allowing it to evaporate and then condense on a cold surface. This process will separate the salt and fresh water. Solar energy can supply heat energy for the evaporating process.

For this investigation you will need:
a two litre plastic cool drink bottle,
a large glass jar (a coffee jar) and a smaller jar that will fit inside the plastic bottle,
some black cloth,
some salt water.

1. Place the cool drink bottle in hot water and twist off the base.
2. Cut the top off the cool drink bottle.
3. Paint the rest of the cool drink bottle black.
4. Set up a solar still as shown in the sketch. Use the black cloth stretched over the bottle at the bottom to hold up the smaller bottle containing the salt water.
5. Place the still in direct sunlight and leave it for about an hour.
6. Taste the water that has collected in the bottom of the coffee jar. Compare it to the remaining salt water.



Answer these questions in your groups:

- What does the collected water taste like?
- Why did we paint the bottle black?
- Why don't we paint the coffee jar black as well?
- Describe how this apparatus uses solar energy to produce fresh water.

This apparatus does not produce a large amount of water because it is very small and can only trap a small amount of solar energy each day.
In your group, try to design an apparatus that you would use to prepare enough fresh water for your whole family.

University of Cape Town

Use of the Sun's energy

There is a danger that the large amount of fossil fuels (like coal) being burnt for our energy needs are polluting the Earth. The Sun radiates an enormous amount of energy to us on Earth. We get more energy from the Sun in one second than we need to keep us going for a whole year.
So why don't we use more of the free energy from the Sun?
There are many difficulties with the large-scale use of solar energy.
One problem is that sunlight is not available all the time.

Another problem is that the Sun's energy is spread over a large area. We would need very large surfaces on solar collectors if we want a lot of energy. Photovoltaic cells which convert solar energy into electricity are inefficient. Only 15% of the energy they receive can be used as electrical energy. From about 1 000 watts per square metre reaching the Earth's surface, only 150 watts of electricity can be generated per square metre.

However, we can increase the quantity of solar energy reaching an object if we reflect sunlight from a large area and direct it onto an object. Engineers have been able to do this with a solar furnace. The furnace can heat objects to temperatures over 500°C.

In your groups, think about and discuss the following:

- How could these factors effect solar energy?

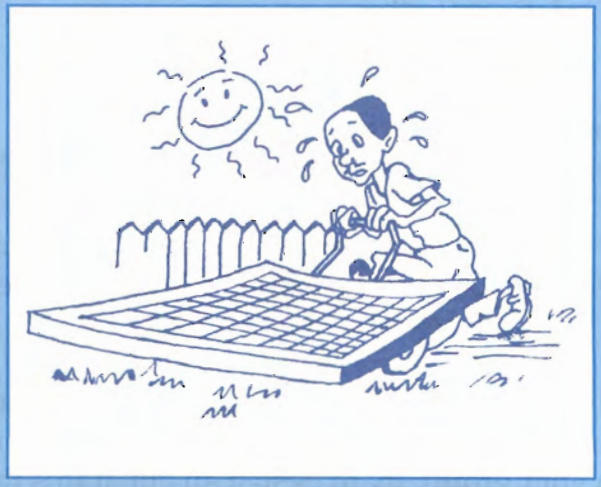
Night	Winter
Clouds	Windless days
Flat landscapes	Seasonal rains
High cost of solar energy converters	

University of Cape Town

Solar power

If a lawnmower needs a 1 000 watt electrical motor to drive it, then to power the motor we will need 6,66 square metres of photovoltaic cells to generate this energy.

Can you imagine the area needed to supply a big city with electricity using photovoltaic cells?



EXPLORING SCIENCE MAKE YOUR OWN SOLAR OVEN

Solar energy can be concentrated and used to heat food, like a magnifying glass is used to burn paper. To do this exercise, you will need:

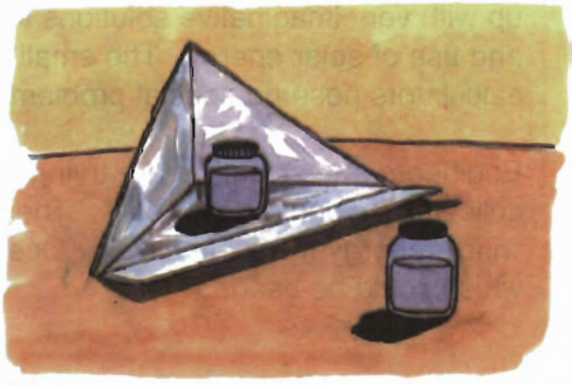
two similar jam jars,
a thermometer,
a large square cardboard box,
aluminium foil (tin foil),
sticky tape or glue,
a small clean black tin or a dark, light-weight metal pot
and a clear plastic cooking bag (big enough to hold the whole pot when closed).

Making the solar energy concentrator



1. Cut the box in half diagonally so that each triangle formed is about the same size.
2. Tape an extra piece of cardboard to the front edge of the bottom triangle to form an adjustable flap.
3. Fix the aluminium foil to the entire inside of the box with its shiny side on the outside.

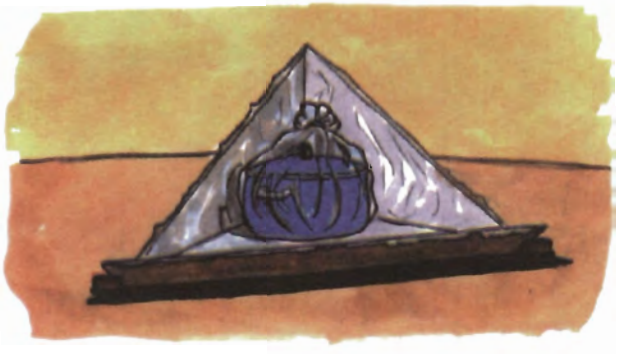
Testing your concentrator



1. Half-fill the two jam jars with water.
2. Record the starting temperature of the water in each jam jar.
3. Place one of the jars in bright sunlight and the other in the concentrator box. Use the front panel to reflect more light onto the jar.
4. Leave the jars for 15 minutes and then take the temperature of the water in both jars again.

- Why are the temperatures different?

Using the concentrator as a solar cooker



Place the food you want to cook into the black pot. Put the pot into the plastic cooking bag. You may need about two hours of strong sunshine to cook the food. Turn the solar cooker around now and then to make sure that the pot is receiving as much radiant energy as possible.

University of Cape Town

Designing your own solar concentrator cooker

In summer, these solar cookers can cook porridge, stew, sausages and heat almost anything quickly. Any design that can reflect the Sun's rays to a small area will work as a solar cooker.

In your groups, build your own solar cooker.
Test the cookers to see which design can boil a litre of water fastest.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

photovoltaic cells	A unit of power - the conversion of 1 joule of energy from one form to another in one second
watt	Devices that convert light energy into electrical energy

WHAT I HAVE LEARNT about the tools of science

Engineers who apply the discoveries of scientists to everyday problems need to use their imaginations. The use of solar energy has allowed many engineers to come up with very imaginative solutions to solve problems associated with the collection and use of solar energy. The small scale use of solar energy in wrist watches and calculators pose no special problem since very small amounts of energy are needed.

Engineers and scientists are trying to increase the amounts of energy which can be collected by photovoltaic cells. They are trying to make better windmills to use the wind's energy more effectively. Ocean tides and waves in the sea also have energy which could be used.

University of Cape Town

4.3 ENERGY IN OLD STONES

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe how coal is formed.
2. Explain the link between sunlight and electricity.
3. Identify ten uses of coal and its by-products.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Describe the physical processes in coal formation.
2. Explain the link between solar energy and the energy in coal.
3. Identify the practical uses of coal.

A journey back in time



The coal we burn to make a fire has a tale to tell - a tale millions of years old. Come with me on a journey back through time, to 300 million years ago, to a strangely silent South Africa... Imagine no cars, no people. It's very quiet. The wind whistles softly in the tops of ferns as tall as trees, soaking up the sunlight. There are no large animals crashing through the tree-ferns. Only the furious clattering of big wings as a huge dragon-fly, almost a metre wide, shoots out of the dense shade, hovers over a dark pool and vanishes again into the fern forest beyond. This is a world of giant arthropods. Strange beetles and scorpions dart and twist in the search for food while snails glide away on endless trails.

In the distance, glaciers glitter in the sunlight. These are left over mantles of ice which once covered southern Africa when the ice was king. The massive ice sheets moved freely back and forth across this land, pushing soil and rock rubble along, gouging out deep valleys here and filling in valleys there.

After this ice age, lakes and swamps formed in the hollows and the climate became warm and humid. During these great summers, plants grew quickly. Lakes filled with decomposing plants and became swamps. These swamps dried up and forests of tree-ferns and moss-like plants took over. These forests died and others grew upon them in their place, millions of times over.

Then another ice age came with another great winter. The returning glaciers with their loads of soil and rock rubble buried the old forests and their remains. This happened over and over again, over hundreds of millions of years. Buried compost lay deep in the earth, layers built up like a giant earth sandwich. Pressure and heat slow cooked this compost into a very dark soil we call **peat**. Under pressure, peat turns slowly into a brown soft coal we call **lignite** (brown coal). More pressure builds up the heat and the layers become the hard black coal we call **anthracite**.

Over millions of years, a seven metre compost layer becomes a two metre layer of coal.
Over millions of years the great forgotten fern forests of Gondwanaland became the rich coal seams of South Africa, hiding their secret energy deep underground.
But let us return to our own time...

University of Cape Town

Let us return to our own time...

When we burn this coal today, we release solar energy trapped by those ancient forests, which grew and decayed many millions of years ago. The light what warms our homes and faces shone on a very different world long, long ago. The flames of a coal fire hide ancient stories of millions of lives and deaths, grinding glaciers and bright sunlight from prehistoric times.



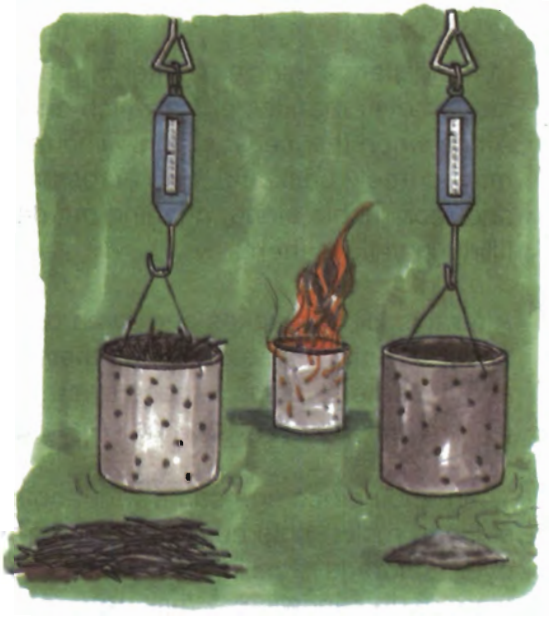
Time traveller questions:

- Where did the plants in the story get energy from to grow?
- What happens to the energy stored in plants when they die?
- How do we reach the coal which is underground?

EXPLORING SCIENCE RELEASING TRAPPED SOLAR ENERGY

As plants grow, they use minerals from the soil, radiant energy from the Sun, carbon dioxide from the atmosphere and water from the soil.
In this investigation, we are going to try and find out how much plant material comes from minerals in soil and how much from the Sun.
You will need:

a spring balance, a coffee tin,
a nail and some dry wood chips.



1. Use the nail to make some holes in the side of the tin.
2. Place the dry wood in the tin and weigh both together. Record the combined weight of the tin and the wood.
3. Light the wood inside the tin and allow it to burn out completely. The ash represents the part of the wood which came from minerals in the soil.
4. Weigh the tin and the ash. Record the weight.

In your groups, answer these questions:

- What is produced when wood burns?
- Where did the heat energy and light which is released by the burning wood come from?
- How does the weight of the ash compare to the weight of the wood?
- How much weight was lost during the burning process?
- Where did this material, represented by the lost weight, go to?
- What percentage of the original weight was lost?
- What percentage of the weight of the wood came from minerals in the soil?

University of Cape Town

Energy from old stones

Coal is a very concentrated form of energy. It took over 300 million years to form coal from decomposed plants. Coal is the fossilised remains of these plants. When we burn coal, this energy is released.

There is enough energy in one kilogram of coal to heat 100 litres of water from 25°C to 100°C (boiling point). In South Africa, we use the energy from coal to generate electricity. Huge amounts of coal are burnt daily to boil water, to drive steam turbines in power stations and to generate electricity for use in industry, our homes and classrooms.

About 60 million tons of coal are mined every year and 30 million tons of this coal is used to generate electricity. ESKOM, our main electricity producer, estimates that by the year 2000, we will need to mine over a hundred million tons of coal a year to produce sufficient electricity for our needs.

All coal formed slowly over a period of millions of years, so there is a limited amount of coal left. This supply is growing less day by day. One day it will all be used up! We say that coal is a **non-renewable** source of energy.

Coal power

- About a third of the energy used in the world comes from coal.
- There is enough coal left for about 200 years.
- The energy in a piece of coal the size of a peanut could run a television set for about two minutes!

Coal dangers!

Many people use coal for fires to heat up their homes during cold winter nights and in cookers to cook their food. But coal fires are dangerous if they are burnt in a confined space without good ventilation (fresh air flow).



When coal burns in a well-aired fire, carbon dioxide gas is produced. But when a coal fire burns in a closed space without fresh air, carbon monoxide gas is formed. This gas is poisonous to humans and can kill people. If carbon monoxide is produced because all the doors and windows are closed, people sleeping in that room may never wake up again!

Be safe - make sure that the brazier (fire bucket) has many large air holes punched in its sides. Also make sure that the room where the fire is burning has some fresh air flowing through it.

University of Cape Town

EXPLORING SCIENCE CHEMICALS FROM STONE

As we know, coal is the fossilised remains of ancient plants.
Plants produce and contain many chemicals and these chemicals remain even when the plants are fossilised!
To show that coal contains chemicals that can be extracted from coal, we must heat the coal.
For this investigation, you will need:

a coffee tin,
a saucer to act as a lid,
some coal,
a brick or hammer
and a source of strong heat (a Primus stove or gas burner).

1. Look at the lump of coal in the sunlight.
   - What do you see?

2. Crush some coal into a powder using a brick. Place about three tablespoons of this coal powder in the coffee tin.

3. Put some water into a saucer and place it over the opening of the tin to act as a cool lid.

4. Heat the tin strongly on the gas flame for about 10 minutes.

5. Allow the tin and coal powder to cool down before removing the saucer.
   Look at the underside of the saucer and the sides of the tin.
   - What do you see?
   - What does it smell and feel like?



University of Cape Town

Modern miracles from old coal

There are many different chemicals in coal. All of them contain carbon in combination with hydrogen. We call these chemicals **hydrocarbons**. In South Africa, SASOL extracts hydrocarbons from coal. At SASOL, four million tons of coal are converted into other products every year.

A form of coal (called coke), is used in the making of iron from iron-rich ores.
Coke is made by heating coal to a high temperature in an large oven until all the gas and liquid parts (hydrocarbons) have been driven off (evaporated). Only the carbon part of the coal remains. This is what we call **coke**. ISCOR (the South African Iron and Steel Corporation) uses about four million tons of coal per year to produce steel.

Products from coal

- Oil, diesel oil and petrol used in all moving vehicles
- Tar and pitch used in road surfaces
- Pigments for paints and dyes
- Chemicals to produce tyres
- Chemicals for use in making of plant fertiliser
- Chemicals used in the making of explosives for mining
- Chemicals used in the making of plastics

Energy in substances in the Earth's crust

Peat
An early stage in the formation of coal.
It is composed of partly-decomposed vegetable matter. It is soft and crumbly and can be cut with a spade into fuel bricks. When dry, it is used to warm homes but makes a very smoky fire.



Lignite
This is a soft brown coal that crumbles easily.
It is an intermediate stage in the formation of hard black coal. It is often burnt to make coke which is a porous, grey, brittle carbon ash. Coke is used as a domestic fuel but is especially valuable in the iron and steel extraction process.



Anthracite
This is a dense hard, shiny black coal that releases a lot of heat energy and burns without producing too many flames or smoke.
It is the favoured coal for burning in domestic fireplaces and in boilers.



University of Cape

WHAT I HAVE LEARNT about coal

In your groups, decide whether the following statements are true or false:

1. Coal is the fossilised remains of dinosaurs.
2. The energy in coal was transferred from the Sun.
3. Coal formed over many millions of years.
4. Pressure and heat are important agents in the formation of coal.
5. Anthracite coal is the most highly developed form of coal.

WHAT I HAVE LEARNT about the uses of coal

Coal is used in many ways in every community. In your groups, write a report on the way in which coal energy or any other by-products from coal are used in your area. Think of electricity, transport (including trains), agricultural chemicals, chemicals used in road building. Consult people whom you think might be able to help you. Use any book resources that may be in local libraries or the Internet.

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

anthracite	Coal which has been heated until all volatile substances have evaporated
coke	The most primitive form of coal
hydrocarbons	Chemicals which consist of carbon and hydrogen only
lignite	The most highly changed form of coal
peat	Coal which is still changing

LEARNING about carbon chemists

The importance of chemicals in coal was first realised during the 19th century when an 18-year-old British schoolboy, Perkin, discovered by accident that the natural blue dye usually found in indigo plants could also be cheaply extracted from coal. Purple or mauve clothes (the colour reserved for royalty since the days of the Roman emperors) became fashionable overnight!

Today there is a large group of chemists who specialise in developing by-products from coal which itself originated from the photosynthetic process in plants. These chemicals all consist of the element **carbon** which may be linked to hydrogen, nitrogen, oxygen or sulphur. We call these scientists **organic chemists** because they specialise in the chemistry of carbon products produced by living organisms. Organic chemists are interested in producing carbon compounds (such as aniline - the indigo dye) and making new carbon compounds (such as plastics and medicines). Their work has greatly improved the quality of life for all South Africans.

University of Cape Town

4.4 LIQUID ENERGY

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe how crude oil is formed.
2. Describe some of the uses of crude oil.
3. Describe how and why oil can be divided into different fractions.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO4 Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilisation of natural and other resources.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Debate the pro's and con's of various energy sources.

A great find

The drilling machine had been working for days in the same place. The air was thick with the dust and grime from the machine incessantly boring into the earth. Sweat poured down the men's faces and their clothes were caked with the dust. This was the team's last chance to find the black gold. The company had started surveying for oil some years before. Budgets had been drawn up and targets were set.



Eventually the heavy equipment was transported to the site. Over the past months, this expensive equipment had been working 24 hours a day, drilling hundreds of metres into the earth. A couple of times there had been excitement as they hit a crack in the bed of rock and awful smelling gas spewed out. But the blow soon stopped and then there was nothing.

Now management was worried. There was only enough money for one more day of drilling. The drilling team would have to be given employment elsewhere and equipment moved out. The men were puzzled. The surveys had indicated that the area was very favourable for finding crude oil. They had drilled deeper and deeper, but had not found the oil.

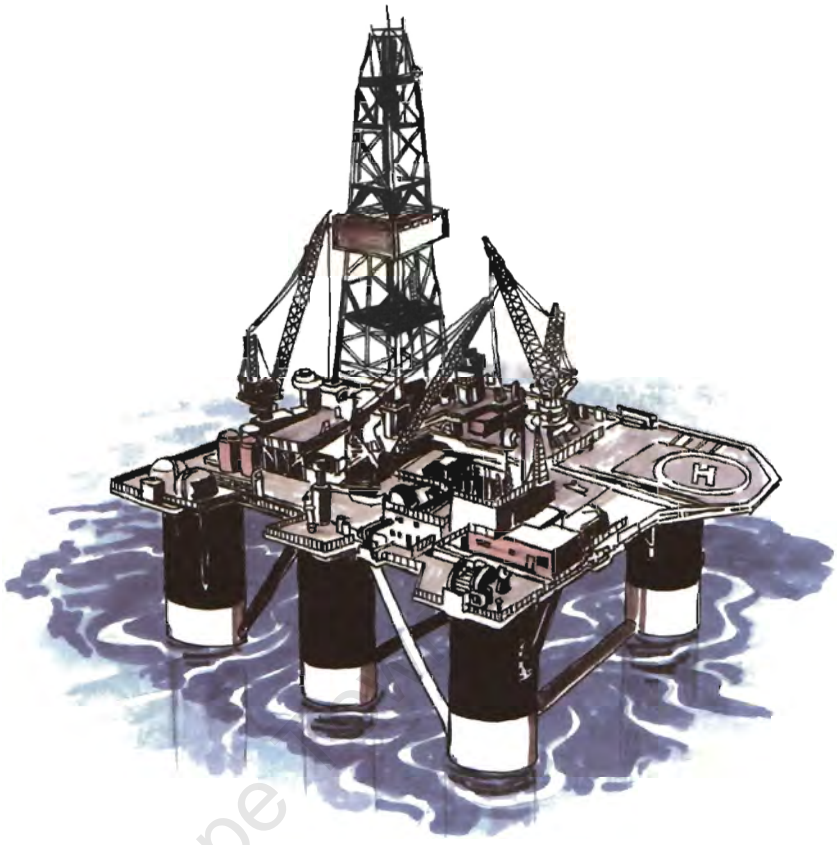
The site manager sat in the hot office, making calculations over and over again. Was there enough money to pull the drill away from its present spot and to return to the hole they had drilled first? That was the spot directly above the rock cave. Perhaps if they drillled another hundred metres down, they would eventually find what they were looking for.

Suddenly there was a deafening roar. The manager looked out of the window. A thick black streak was gushing up into the sky. Up and up it went, eventually steadying, stopping and then spreading out as the oil fell back to earth. The team was shouting in excitement and dancing in the thick oily shower. They had finally struck oil!

How much do you know about crude oil? Discuss these questions in your groups:

- Which countries have oil wells?
- Does South Africa have any oil wells?
- What does crude oil look like?
- What do we use crude oil for?

The story of oil



Oil and natural gas are **fossil fuels**, like coal. Oil and natural gas are mixtures of **hydrocarbons** which were formed from the remains of tiny sea animals and plants called **plankton**. These tiny life forms lived in shallow seas hundreds of millions of years ago. The plant forms built up their bodies through the process of photosynthesis. The tiny animal forms fed on these plants.

Nobody knows for certain how the tiny bodies of these sea animals formed oil when they decayed. The most popular theory is that the dead plankton sank slowly to the bottom of the ocean. They were then covered by sand. Under the water and sand there is almost no oxygen and the plankton decayed into a mixture of gases and a thick, dark liquid called **crude oil**.

The crude oil moved through porous rock layers and collected under dense rocks which it could not penetrate. There it remained in oil traps. Today we believe that there may be about 135 billion tons of gas and 112 billion tons of oil remaining in these undersea traps. At our present rate of use there is enough oil left for about 40 more years and enough gas for about 60 more years!

Crude oil is a mixture of many different chemicals which consist of carbon, hydrogen, nitrogen and perhaps some sulphur. The main use of oil is for heating. Fuel oil is burnt to produce electricity. Diesel oil and petrol is obtained from crude oil and used in car engines. Hundreds of different carbon compounds have been found in crude oil. It is used in lubricants, waxes, solvents, tars for use on roads and roofs. It is also the source of chemicals used in the production of medicinal drugs, plastics, pesticides and fertilisers.

The petrol used inside the engine of the car, taxi or bus taking you to school is one by-product of crude oil. The trapped energy of the sun is at last released and transferred to move a car or a bus. In South Africa, mixtures of oil and gas were found near Mossel Bay after an extensive search by SOEKOR. The gas and oil mixture is treated on land by the MOSSGAS plant just outside Mossel Bay.

But crude oil can't be used as it is to drive cars! We have to separate the different chemicals in crude oil to get the petrol we can use.

University of Cape

EXPLORING SCIENCE SEPARATING GAS AND WATER

In this investigation, we will learn about how to separate substances in almost the same way that scientists use to separate gas and oil.
For this investigation, you will need a small cool drink in a plastic bottle. (Fizzy cool drinks contain carbon dioxide gas in a solution of water.)

You will also need:
a small plastic container,
a large jam tin half-filled with hot water
and a thermometer.



1. Leave the cool drink in a cool place for a while. Squeeze the bottle. Notice how difficult it is to make dent in the bottle.
   Now shake the bottle and squeeze it again.
   - How difficult is it to squeeze the bottle the second time?
   - Why is it more difficult to squeeze the bottle?

2. Remove the bottle top.
   - What happens?
   - Why does this happen?



3. Pour some cool drink into a small plastic container. Take its temperature and record it.
   Place the container inside the large tin holding hot water.
   - Describe the behaviour of the cool drink in the small container.

4. Take the temperature of the cool drink after about five minutes. Record it.
   - How does it compare with the starting temperature?



Challenge:
Think about these investigations.
Try to explain these ideas in terms of the factors that influence the solubility of a gas at different pressures and temperatures.

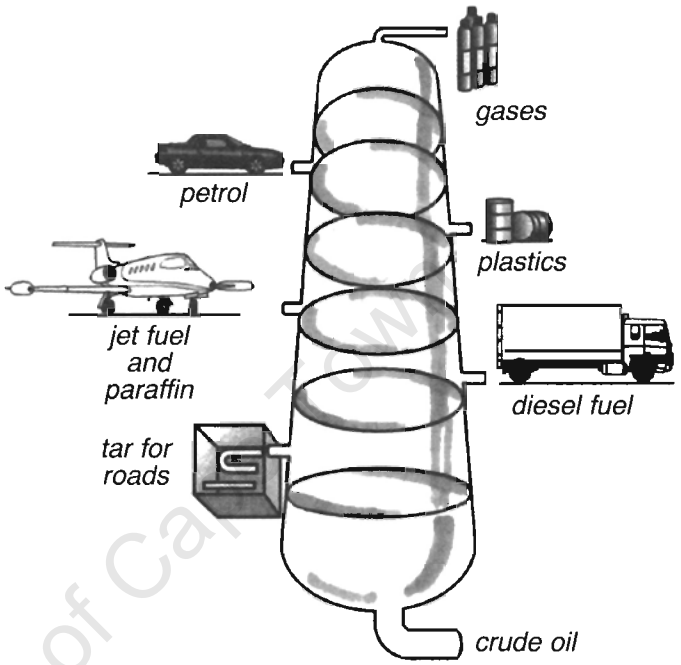
University of Cape Town

Separating crude oil

Crude oil and natural gas are usually under great pressure in their underground or underwater traps. The gas dissolves in the oil. When such a trap is found and opened by drilling, the solution of oil and gas is brought up to the surface. The pressure at the surface is much lower than in the rock trap and the gas comes out of solution.

Crude oil contains a large number of different hydrocarbon components or **fractions**. Chemists have learnt that the different chemical fractions have different boiling points. Petrol is the name for the fraction which boils between 20°C and 90°C. Paraffin is the fraction which boils between 160°C and 250°C.

Chemists use this difference in boiling points to separate the chemical fractions from each other. This process is called **fractional distillation**. The apparatus used in this process is called a fractionating column.



Fractional distillation separates crude oil into different components

Crude oil is heated until it boils and turns into a mixture of hydrocarbon gases. This hot gas is fed into a high column and as the gases rise up the column, they cool and the different fractions condense at different temperatures and are removed for further treatment.

How would these principles affect crude oil as a mixture of different gases and liquids when it is pressurised and heated?

Any gas still in solution is removed during this fractionation.
The gas may be burnt or used for heating or, if there is enough of it, to produce other chemicals.
Gas from the wells near Mossel Bay is used to produce oil and many other chemicals at the Mossgas plant.

University of Cape Town

WHAT I HAVE LEARNT about fossil fuels

In your groups, discuss the following questions:

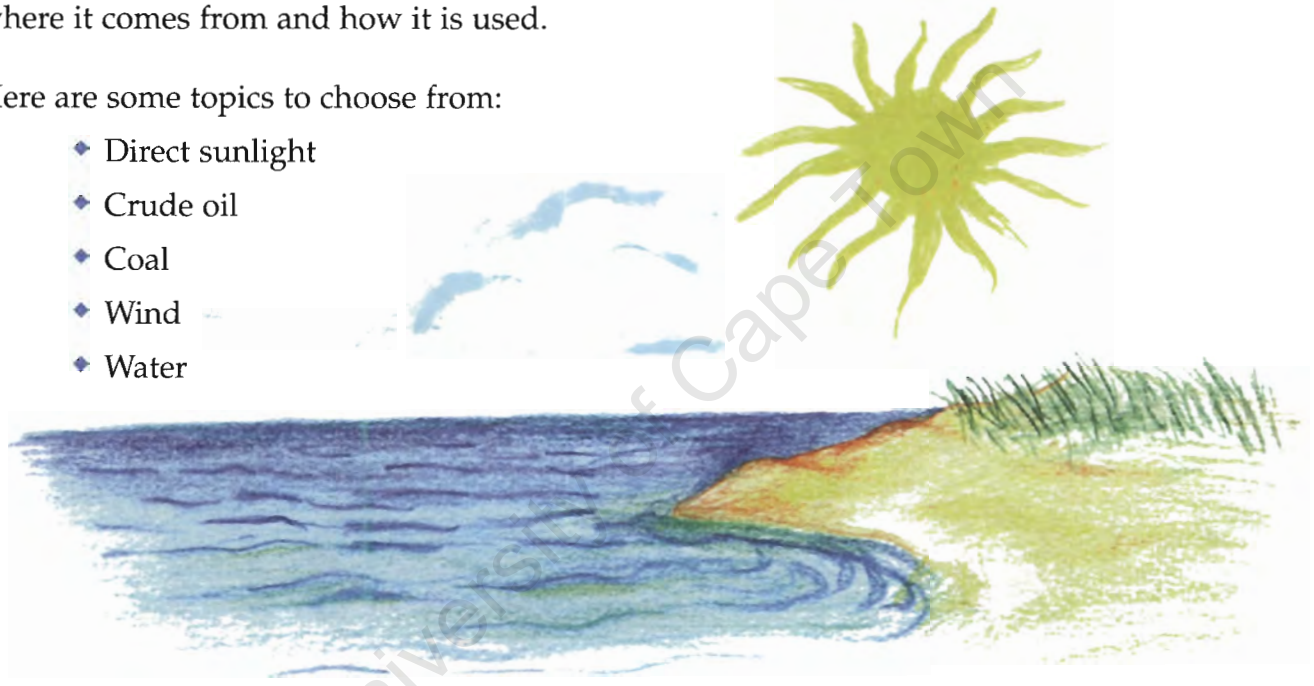
1. What is a fossil fuel?
2. Why do we say that fossil fuels are non-renewable?
3. What is the difference in the production of coal and oil?

The great solar energy debate

In your groups, choose a source of energy.
Prepare a report which explains what your energy source is, where it comes from and how it is used.

Here are some topics to choose from:

- Direct sunlight
- Crude oil
- Coal
- Wind
- Water



University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

natural gas	A fossil fuel usually found together with oil
fractional distillation	The process by which oil is separated into different parts with different boiling points
crude oil	A liquid mixture of complex hydrocarbons formed from microscopic marine animals and plants

WHAT I HAVE LEARNT about the tools of science

Chemistry is the branch of science which concerns itself with how materials behave in the presence of other materials. By investigation, chemists have discovered many properties of different materials. These properties are divided into chemical and physical properties. **Chemical properties** describe how materials react with each other. **Physical properties** refer to what we can observe with our senses or measure with instruments.

For example, the colour of a substance and its boiling point are physical properties. If two substances have a physical property which is different from each other, (perhaps one dissolves in water and the other doesn't), the difference may be used to separate a mixture of the substances. It is knowledge like this that is discovered by chemical engineers and that helps huge chemical plants to separate chemical substances at mines.

University of Cape Town

LIVING IN THE AIR

5.1 THE SECRETS OF FLIGHT

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain how birds and insects fly.
2. Appreciate the link between bird flight and modern gliders and aircraft.
3. Design, build and test paper gliders to achieve maximum glide paths.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate a Natural Science phenomenon.
NS-SO9 Recognising the interaction between Natural Science and development.
T-SO1 Applying the technological process to a design problem.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Explain how birds and insects fly.
2. Appreciate the link between bird flight and modern gliders and aircraft.
3. Design, build and test paper gliders to achieve maximum glide paths.

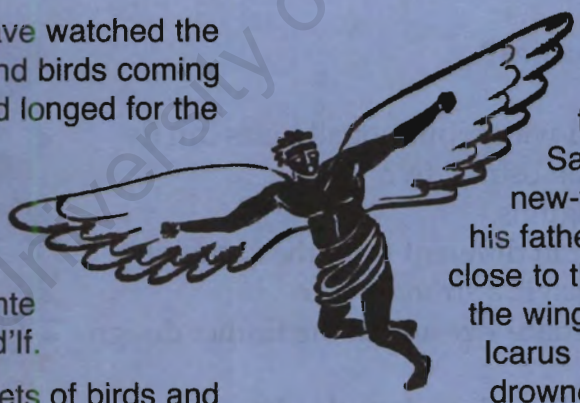
Escape from Robben Island

Robben Island is no longer the notorious prison where our famous political prisoners were kept 11 kilometres off-shore from Cape Town. Round the world, islands have always been favoured places for prisons because it is almost impossible to escape from them.

Prisoners, in despair, have watched the total freedom of the island birds coming and going every day and longed for the power of flight...
Nelson Mandela on Robben Island, St John on Patmos Island, the Count of Monte Christo at the Chateau d'If.

Some prisoners make pets of birds and feed them. Others, like the Birdman of Alcatraz, study birds carefully to find out the secrets of flight.

Some try to copy birds, like Icarus and Daedalus in the Greek myth. In this legend, these brave Greeks collected feathers and used bees' wax to mould wings which they strapped to their arms.



With these wings, they flew away by flapping. Sadly Icarus, enjoying his new-found freedom, ignored his father's warning and flew too close to the sun. The wax melted, the wings disintegrated and Icarus fell into the sea and drowned.

Study this picture of a gull in flight.

- How do you think this bird flies?
- How does it use its wings?
- What is the difference between the up and down strokes of the wings?
- What does the tail do in flight?



Discuss the story in your group and try to work out a theory of your own.

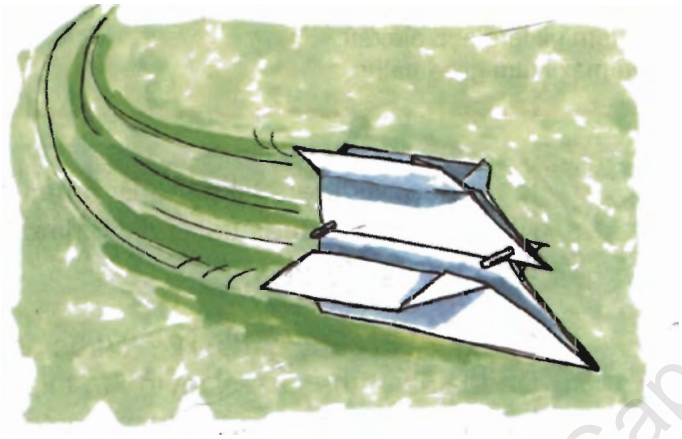
- Why do you think the story of Icarus and Daedalus's escape could not have been true?
  Report your findings to the class.

University of Cape Town

EXPLORING SCIENCE GLIDING FLIGHT

Design and build a super-glider in your group and see which glider can fly the furthest distance.
Each group will need: two sheets of A4 size paper and two paper clips.
Test your models outside. Investigate different designs.
Try different wing sizes and attachment points.

- What difference does the launching angle make?
- Do flaps help or not?
- Which design seemed best?



This design worked well for me. Can you beat it?
What can you learn from the shape of aircraft wings?

Jets and birds

When a big passenger jet like a Boeing 747 throttles back, it falls from the sky in a controlled glide. The pilot keeps the plane in the air at a slow speed by enlarging the wings. This happens when he pushes out additional flaps to increase the plane's lifting power.
Birds do this as well.
Do you know how?

What makes birds special?

All birds have feathers and wings, but not all birds can fly.
Why can't a penguin and an ostrich fly?
Look at this picture of penguins.
How is the flightless penguin different from the sacred ibis in the picture below? Which is a strong flyer?
The secret is in the wing surface size and in the feather design.



Penguins can't fly because they don't have big broad quill feathers on their wings. Their bodies are streamlined for swimming, but not for flying. Bird flight is more complicated than aircraft flight and birds have much more to do in the air than aircraft.



Birds have no engines to push them through the air. They have to rely on moving their wings to lift and drive them through the air. Their wings change position, shape and size all the time while they are flying - to help them turn, lift, speed up and slow down. There are many different patterns of flight - flapping, gliding, soaring, hovering, tilting, diving and then landing safely again.

University of Cape Town

Flapping to fly

Birds fly by flapping their wings. This produces power for forward movement and lift for flight. Birds have special large breast muscles for this work. They also have a large strong heart. Their bones are light and hollow and their quill feathers increase their body size to make flight easier.

Gliding flight

This flight is used when descending. When a bird glides, it doesn't flap its wings. As it glides, the bird starts to lose height and it comes down to the earth. Gliding flight is common to birds like geese, swallows and seagulls. It looks effortless. The tail feathers act as a brake to reduce the bird's speed to a controlled stall. As the bird lands, it folds its wings quickly and neatly.

Soaring flight

Where warm air currents (thermals) rise up from the hot ground, birds make use of these thermals to soar (a rising glide) to great heights by circling round and round inside the rising thermal. Long-wing glider pilots also use these thermals to increase their lift. Birds with large wings are able to hover in the rising air by fanning the feathers at the tip of their wings back and forth to control direction. From these great heights large birds like hawks, vultures and eagles swoop down on their prey far below.

Hovering flight

While hovering, birds seem to hang in the air in one spot, with their wings beating quickly. Sunbirds, sucking nectar from flowers, flap their wings so fast that you cannot see their wings. No humans, especially not Icarus and Daedalus, ever got off the ground by flapping large wings! Our chest muscles are not strong enough and our bodies are the wrong shape. We have more strength in our legs than in our arms. Flying requires more than just flapping large feathered wings.



University of Cape Town

EXPLORING SCIENCE BIRD WATCHING

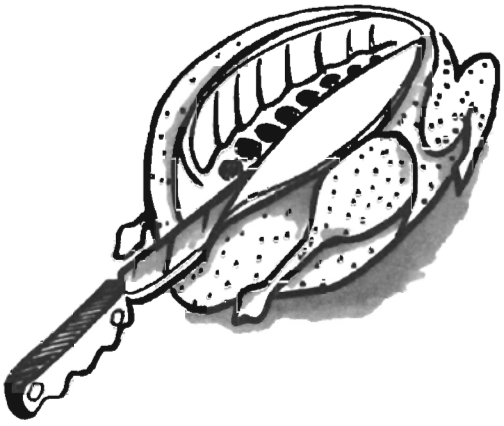
Go into a garden and throw some seed or bread crumbs on the ground. Hide yourself behind a bush or under a tree. If you are patient and watch carefully, you will be able to see for yourself how birds fly. Make notes of the birds you see.

- Where do the birds come from?
- Are there any special behaviours, e.g. pecking or chasing other birds.
- What advantage may there be in doing this?
- Watch how they land. What role do the tail feathers and legs play in landing?

Watch the birds take off.

- What do the legs do? Do the wings beat up first or down first?
- How do they move forward at first, in a steep climb or a low flight path? Why?
- Do the wings beat up and down or diagonally backwards and forwards?
- How much longer than the birds' body are the wings when unfolded?

Next time you have chicken for a meal...



- Measure the length of the body and the wings.
- How is the chicken's breast bone different from yours?
- Why is there a big difference?
- Which muscle meat is browner after cooking - the chicken's legs or its breast?
- What does this tell you about how wild fowls live and behave?

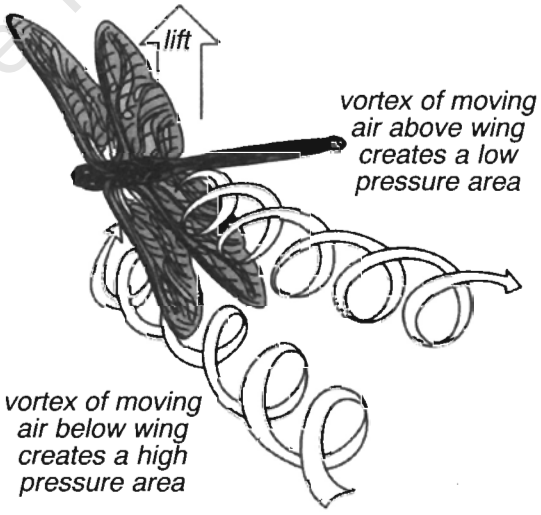
Two solutions, one problem... how to fly

Although birds and insects are completely different in body structure, they can both fly! Insects don't have any feathers. Yet locust swarms can fly as far as 200 kilometres a day. Looking at the design of any insect body. The wings seem to be unable to create enough lift for flight. They are small, even if they have four wings, and there is no room for big breast muscles either.

Insect flight

Insect flight was a mystery until recently when scientists began to do tests with insect models in wind tunnels. Only then did we begin to learn the secrets of insect flight.

As the insect wing begins to beat, a vortex of moving air (like an invisible twister or cyclone) is created above the wing. This creates a low pressure area above the heavy body and it lifts. A vortex moving in the other direction below the wing creates a high pressure area under the body and it rises, thrusting the body upwards. Insects can rise almost vertically into the air when they start to fly!

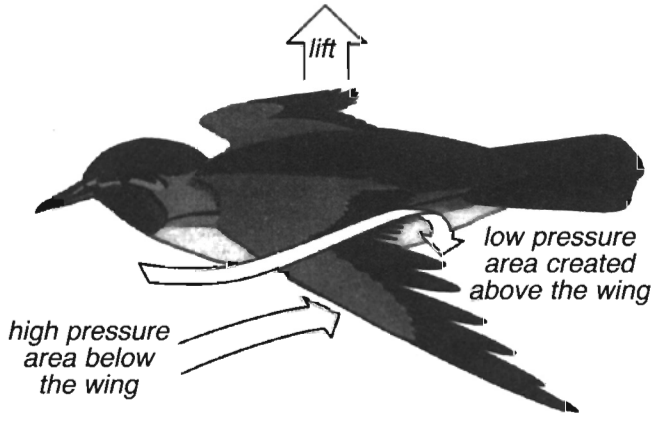


Insect flight

University of Cape Town

Bird flight

As the bird's wing moves forward, air rushes over the wings which are curved to create lift. Where the air moves faster, a low pressure area is created and lift occurs because a high pressure exists below the wing thrusting it upwards. Aircraft wings are also curved like this.



Bird flight

Study this diagram of a duck's wing beating downwards and upwards.

Put a ruler along the line of the duck's head positions.

- What do you notice?
- Look at the wing shape where the lift is greatest. Explain this.
- Where are the wings when the duck is sinking? Explain this.

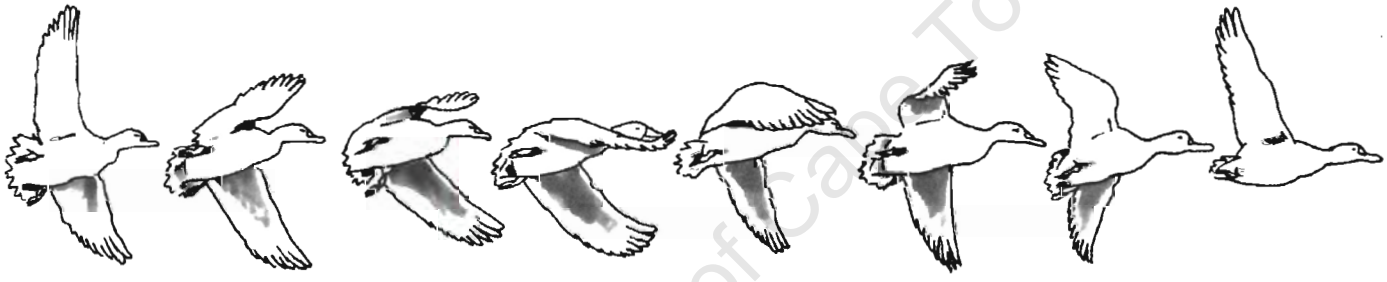
Place a ruler through the point when the wings attach to the duck's body. Move it along to each position of flight.

- What do you notice now?
- How does this backwards and forwards movement help the bird to move forwards?

Look at the big feathers on the wing tips.

- When are they open and when are they closed?
- Can you see what is happening?

The wing tip feathers can change their angle like aeroplane propellers. This helps to push the bird forward.



University of Cape Town

WHAT I HAVE LEARNT about bird flight

Fill in the missing words in the following paragraph. Use the words listed below:

In order to fly, a bird kicks its legs_____ and lifts into the air as it raises the wings_____ . It continues to fly by _____ the wings up (_____) and down (_____). The upstroke is faster than the downstroke. As the wings are being pulled downwards, the wing tip feathers sweep the _____ backwards, like oars pushing the bird forward. The air _____ above the wing is lower and causes the air below to push up, giving a upwards_____. So flapping its wings keeps the bird up and moves it forwards.

upwards	**pressure**	**air**	**upstroke**	**heels**
keeps up	**backward**	**flapping**	**downstroke**	**thrust**

Use what you have learnt in this module to compare bird and insect flight.

Remember these new ideas

You have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

thermal	To be pushed up or forward in the opposite direction of the effort applied
thrust	A column of warm air that rises up

WHAT I HAVE LEARNT about the tools of science

The discoveries of science require careful, patient looking (observation) and thinking about what you see. There is always much more to be seen than appears at first. Watch carefully, take notes and think about what you see - you could be rewarded with an idea of how something works.

University of Cape Town

5.2 MEALS ON WINGS

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify the most practical solution for controlling birds at airports.
2. Investigate the effect of bird of prey silhouettes on other species of birds.
3. Tell the difference between the facts of owl ecology from cultural taboos and myths based on superstition.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate a Natural Science phenomenon.
NS-SO3 Applying scientific knowledge and skills to problems in an innovative way.
NS-SO6 Understanding the relationship between science and culture.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify the most practical solution for controlling birds at airports.
2. Investigate the effect of predator bird silhouettes on prey species of birds.
3. Distinguish the facts of owl ecology from cultural taboos and myths based on superstition.

Flights into danger



New York's J.F. Kennedy Airport, Entebbe International Airport and other airports in Israel, Canada, Taiwan and in Europe are plagued with unauthorised flights of birds which congest the busy skyways above these airports. Airport controllers are at their wits' end to know what more to do to ensure the safety of their passengers.

Birds and Boeings, or for that matter any jet aircraft, are a recipe for disaster... and it happens! In 1997, six aircraft hit storks or sucked them into jet engines at Entebbe. A Uganda Airlines Boeing 737 was forced to make an emergency landing after hitting a marabou stork on take-off. It cost about R1,2 million to repair the plane. In 1995 at Kennedy Airport, a departing DC-10 crashed after sucking sea gulls into its engines. In 1995, an Air France Concorde flew into a flock of geese. The damage cost R25 million. Israel reports that more fighter jets have been lost to birds than to enemy fire. Some authorities believe that it is only a matter of time before there is a major international aircraft disaster caused by birds flying over the runways.

Birds are found near airports where the flight paths are sited across traditional migratory routes or near feeding grounds or refuse dumps. Also, where long grass can shelter young birds and their food species, where people are excluded and the birds are undisturbed. Many innovative solutions to this problem are being tried out by airport authorities - loud sounds, covering rubbish tips, draining ponds, spraying insects, shooting birds, and falconry. Falcons are birds that are used to chase and kill other species of birds.

In your groups, discuss the problem of birds near airports.

- Consider which suggested solution is the most practical.
- What are the advantages and disadvantages of each solution your group suggests?

University of Cape Town

EXPLORING SCIENCE — WHEN THE BIRDS WON'T FEED

For this investigation, find an open area surrounded by trees.
You will also need:

a length of very fine wire or nylon line (twice the width of the open area), a plastic drinking straw and a roll of sticky tape.

1. Stretch the line tightly across the open space between two trees about two or three metres off the ground.

2. Make a variety of black painted cardboard outlines of flying birds. These can be taped onto the straw and then pulled one at a time across the feeding ground when birds are feeding below.

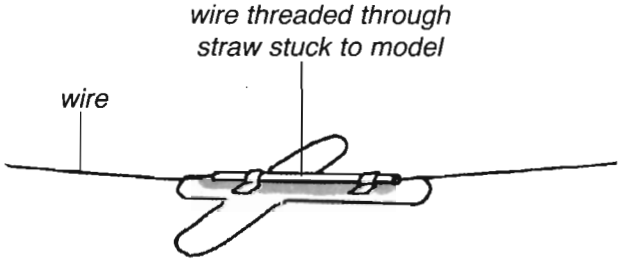
3. Sprinkle about two cups of chicken mash or similar bird food in the centre of the area. Do this for a day or two so the birds get used to finding food there.

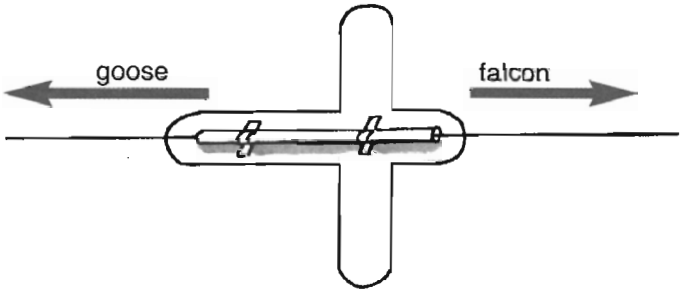
4. Observe which birds come and how they eat. Pay special attention to their feet and beaks.

5. Once the birds are feeding confidently, move the silhouette steadily back and forth on the wire above the feeding birds.

6. Note how the birds respond to different shapes.
   - Does the speed or direction of movement make any difference?
   - What do the scare shapes have in common?







Your model could be shaped like this.
It will look like a goose if it is pulled in one direction; and a falcon if pulled in the other direction.

© University of Otago

The amazing tools of birds

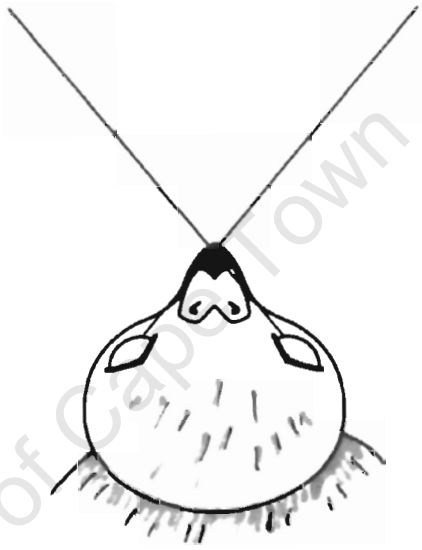
Apart from the wonder of wings, birds are also well equipped for feeding. They do not have hands to clutch or dig. Their feet do this work, holding everything from messy fruits to wriggling snakes. Birds of prey have the most highly specialised feet. They have the sharpest eyesight too. A vulture can see food hundreds of metres away.

Bird eyesight is either:

- wide field, on either side of their heads, for 360° (all round) vision; or
- stereoscopic forward vision (vision through both eyes together) for accurately judging distances.



Doves have eyes on either side of the head for wide field vision



Owls use both their eyes for stereoscopic forward vision

Some birds have telescopic eyes that can magnify objects up to eight times their natural size!

- Which type of vision would a falcon need for its task at airports?

The beaks of birds are their most unique tools. Birds use their beaks to eat roots, grass, buds, leaves, seeds, fruits, nectar, insects, caterpillars, lizards, worms, fish, other birds, mammals, snails and snakes. No one kind of beak can eat all of these foods. There are special beaks for special tasks. The design of a bird's beak is a clue to its diet.



A falcon

University of Cape Town

EXPLORING SCIENCE STUDYING BEAK TOOLS

Birds have no hands, no teeth and eat some very live food with their claws and beaks alone. Try to eat one of your sandwiches without your hands and you will soon know why the vulture has no feathers on its head!

In this investigation, match the birds listed in the left column with their beak tool types in the right hand column.
You will need to make a drawing of the beak shape in the central column.
When you have done this, match the beaks with their function or use in the third column.

You will need to find pictures of these birds if you don't already know what they look like. Use reference books to help you.

BIRDS	BEAK SHAPES	USED AS A
Budgie		Probe
Gannet		Nutcracker
Flamingo		Strainer
Vulture		Spoon
Woodpecker		Spear
Shrike		Meat hooks
Owl		Hammer drill
Sugar bird		Tweezers
Parrot		
Duck		

University of Cape Town

Birds of fate - Owls of the night

Many people fear the owl as a bird which brings bad luck or bad news. The word 'owl' in some older languages is the same word as witch, and they are often associated with witchcraft. People are afraid to hear the call of an owl in many parts of the world. This fear has caused owls to be driven away from homes and killed.

Discuss this in your groups:

- What do you know about owls?

Discovering the facts about owls

The spotted eagle owl in the illustration is the owl most often seen or heard in South Africa.

- Look at its head. Where are its eyes?
  Why do you think its eyes are positioned where they are?
- What sort of beak does it have?
- What does this tell you about its food?
- What sort of animals do you think the owl eats?

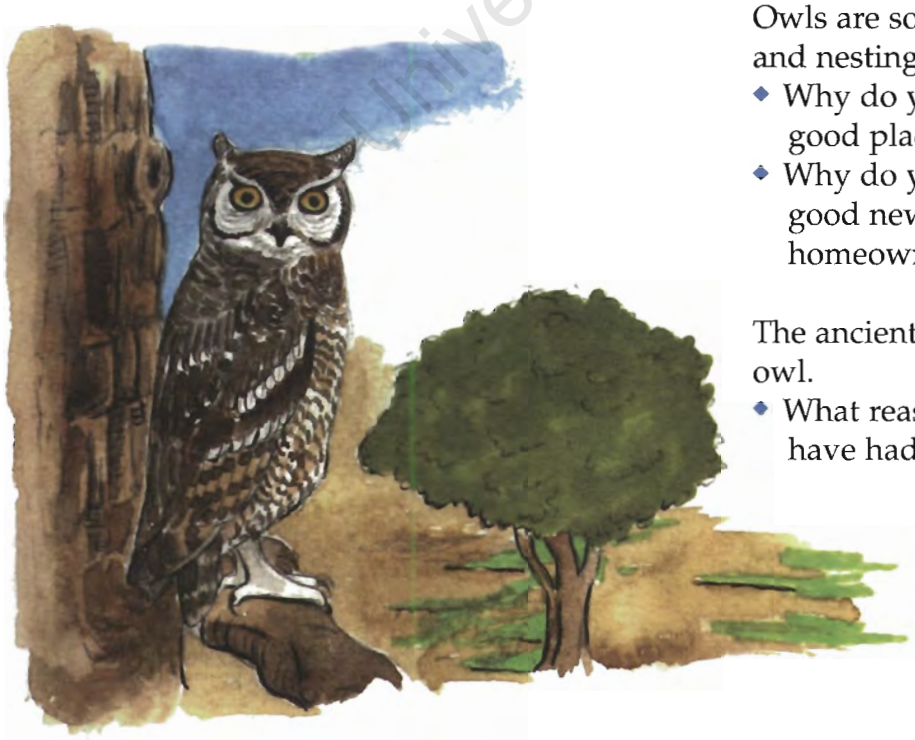
Despite being found in many places, there are not many owls left. Owls can often be seen perching at the roadside.

- Why do you think the owl does this?

Thousands of owls are killed on the roads each year.

- How and why does this happen?

University of Cape Town



Owls are sometimes found roosting and nesting in gardens and buildings.

- Why do you think this would be a good place for owls to roost?
- Why do you think this could be good news for the gardener or homeowner?

The ancient Greeks learnt to respect the owl.

- What reasons do you think they may have had for doing this?

WHAT I HAVE LEARNT about science and cultural taboos

The owl is a feared bird in some cultures. Other cultures regard owls as very wise and all-seeing birds. The facts of science suggest that neither of these interpretations is correct. We do not have to look far to find the possible origins of this cultural belief (taboo). Owls are different from other birds - they have startlingly large eyes that can see well in the dark. Their heads turn around on a very flexible neck which helps them to watch everything without turning their bodies around. Owls seem to be constantly alert at night. They fly after dark, hunting down the rats and mice that are their prey.

All of this makes the owl seem to have magical powers. So, in some cultures an owl is seen as the symbol for a witch. Why? Owls fly at a time when people believe evil things are done under cover of darkness. In communities where little is known about the workings of nature, superstitious ideas can grow! For example, unexpected sicknesses may seem like the work of a spell-casting witch. The watching owl, often seen only by its large eyes shining in the dark, can seem like a witch's messenger of evil.

There is, however, another interpretation of an owl's habits. The owl is a useful controller of rats and mice that raid our food supplies and multiply near our homes, often carrying diseases. The watchful owl, equipped with large night eyes and a razor-sharp, hooked beak swoops down silently out of the trees to help us get rid of these pest creatures. The owl is designed to fly at night and catch its prey. Owls are useful to us because they control rat and mice populations and help to protect our food supplies.

University of Cape Town

5.3 KNOWING WHERE YOU ARE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify the main factors which effect bird migration patterns and navigation.
2. Identify common local birds and keep accurate records of your sightings.
3. Design and make an effective bird shelter and/or feeding table.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate bird behaviour.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Applying scientific knowledge to local bird conservation in innovative ways.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify factors which influence bird migration patterns and navigation.
2. Identify and keep accurate records of bird visitors to a local area.
3. Design and make a bird shelter and/or feeding table to promote bird conservation.

The Flying Fishermen



The long chain of black birds came straggling past me down the West Coast. An unending line of birds, linking together and then separating again and again, rising and falling like the rippling waves of the ocean, disconnecting and catching up again. I was watching one of nature's greatest miracles - the Cape cormorants coming back from their winter breeding grounds in Congo, Angola and Namibia and streaming southwards down the Skeleton Coast following the silvery sardines to Cape Town, the feeding grounds of fish and birds alike.

Adult breeding pairs and youngsters flew together, calling to each other in the loneliness of the long tiring migration, fighting the ceaseless wind over one of the world's most forbidding coastlines - the dry, sandy coastline of the Skeleton Coast.

Now and then, the leading birds flew over a shoal of fish. There was a turmoil of frenzied, diving, black bodies knifing into the water and much energetic swallowing by the birds. The sea boiled with life at such times. At dusk the weary birds would roost somewhere on the desolate coast, great parades of black sentries, together in the greatest annual adventure of their wandering lives. In spring they would feed off Cape fish. From November they would follow the shoaling sardines up the warm coast of KwaZulu/Natal. How did the birds manage to travel so far and find their way back home to the West Coast again on their endless 10 000 kilometre journey following the long coast of Africa?

In your groups, discuss this story:

- Draw a map of the route of the birds and record when they reach different places.
- Why do they migrate?
- What do you think is the threat to the survival of the individual cormorant?
- How do they know the way to go to the feeding grounds and the way back to the breeding grounds?
- What effect would an oil spill from a tanker have on these birds?

University of Cape Town

EXPLORING SCIENCE KNOWING WHERE YOU ARE

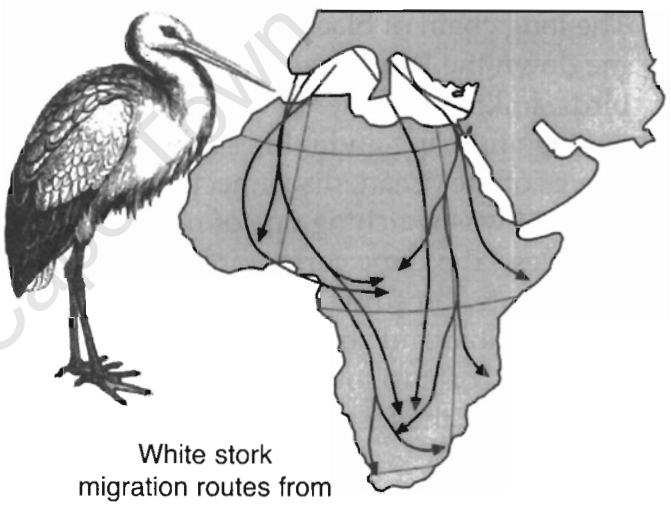
We need two measurements to find out where we are on Earth:

longitude (measures distance east or west of Greenwich in London); and
latitude (measurements north or south of the equator).

Today satellites can instantly plot our exact position to a hand-held meter giving exact latitude and longitude. But if you don't have one of these meters, instuments like a radio, watch, almanac or sextant will supply enough information to tell you where you are. Birds don't have access to this technology, but they still can find their way around effectively and can fly from the northern hemisphere to the southern hemisphere and back.

How birds navigate over such vast distances is still a mystery, but there are several clues. Birds can navigate by:

- watching the angle of the Sun;
- sensing the local shape of the Earth's magnetic field;
- watching the stars;
- avoiding large stretches of water and mountains;
- following the rivers, valleys and coastlines they can see;
- following the summer rains, farmlands, grasslands and insect movements.



White stork migration routes from Europe to southern Africa

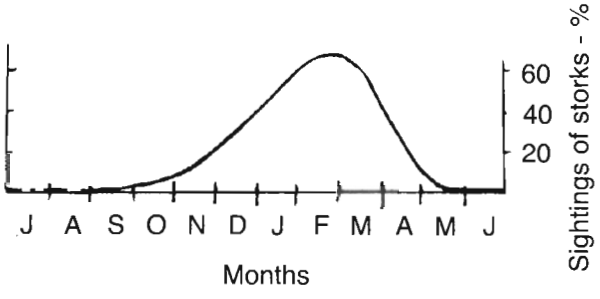
Study the main migration routes of the white stork using a physical map of Africa.

- Which of the above navigation ideas seem to be supported by the routes chosen by the storks?

University of Cape Town

Why white storks diasappear in winter

About 80 of our 8 000 bird species migrate. Some birds come from Europe for our summer to escape the European winter. They fly almost 12 000 kilometres a year from Europe and back!



These birds fly south to find the rich feeding grounds of Africa and to avoid the cold northern hemisphere winter. They return fat and well-fed in time to breed in their traditional nesting areas for the European summer (during the South African winter).

Study this graph of the sightings of the white stork in the eastern parts of South Africa.

- When do these storks arrive from Europe and when do they return to breed?

WHAT I HAVE LEARNT about bird migration and navigation

Complete these sentences:

1. Migrant birds prefer to feed in Africa because...
2. Migrant birds find their way by means of...
3. The two key factors which trigger migration are ...
4. The main threats to migrating cormorants are ...

EXPLORING SCIENCE BIRDS IN YOUR GARDEN

Choose a sheltered bird-friendly spot in your garden or school ground for observing birds. There are two ways to watch birds: go where birds are feeding and use binoculars to watch them; or encourage birds to feed in a place where you can watch them easily.



Birds need trees for shelter and nesting sites, permanent clean water, and a safe place to get food. You can encourage birds to come to your observation place by providing these three requirements.

- Can you provide what birds need near your school or home?

1. Investigate the trees that birds in your area seem to prefer. If you do not have any near your school, go to a plant nursery or farm and find out if they are willing to donate or sell trees at reduced prices for your school grounds.
   Also collect seeds from bird trees and start your own tree nursery in plastic bags. Find out from books and gardeners about the best places to plant trees and how to care for young trees. Mulberry and guava trees are hardy, grow fast and birds love their fruit. Nectar-sucking birds love honeysuckle hedges and red-hot pokers.

2. Make a water fountain. Provide a shallow bowl half-filled with pebbles and water not more than four centimetres deep. Investigate the best place for this water supply to encourage birds to come to a place where you can watch them.



3. Make a feeding table which is at least two metres above the ground. One of the best places is on a shelf outside a classroom window that is sheltered from the wind. You will need to put different foods on this table to attract a variety of birds. Remember that some birds are seed-eaters, some eat fruit and others may eat a variety of foods, including meat.

University of Cape Town

Observing birds



1. To watch birds, you need to have patience! Even with food on the feeding table, it will take the birds some time to get to know that the food site is safe. The good news will get around after about two weeks.

2. Put a variety of foods on the table such as grain seeds, old fruit in a plastic net pocket, bacon rinds and dripping, cheese, shreds of minced meat, bread and stale cake softened in water, crushed egg shells and chopped hard-boiled egg, dead insects (a bowl of water under a light at night can trap moths).

- Keep a record of the types of birds that visit your table.
- Find out what their names are.
- Record what time of day they visit the table, how many of each species come and what foods they prefer.

Check what happens during the different seasons of the year.
Try to see where the birds carry the food to.

- Are there any nests in trees or bushes near your table?

University of Cape Town

Other good ideas:



1. If there are no nests around your area, you may want to provide some nest boxes for the birds.
   There is no one shape that suits all birds. Find a book on bird nesting box designs. Birds of different sizes need bigger or smaller boxes with bigger or smaller entrances.
   All nest boxes need to be sheltered from the wind and rain and should be at least two to three metres off the ground.
   High up under the eaves of the roof is a good spot for a nest box.
   Don't forget to supply some nesting material near the nest boxes in a plastic net pocket, e.g. wool, string, feathers, grass.

2. If you find a nest, study it carefully without disturbing or touching the eggs.

- Keep a record of where the nest is, when it was built, how it was built, what it was made of, how many eggs are in it, what care the parent birds provided and when the young birds left the nest.

The risky passage



Even some of the tiniest birds migrate. The small European Swallow flies out to our country in huge flocks in November, roosting in great numbers in reed beds. They fly almost all the time, catching insects as they migrate, taking about 30 days to reach us. They travel almost 300 kilometres each day! For this long trip, they build up great reserves of body fat (as much as 50% of their weight) to use as fuel.

As many as 80 million swallows attempt the 12 000 kilometre trip twice each year. It is a risky passage! Millions of birds die along the way. Strong winds can blow the birds off course away from food and known routes and a headwind can stop them altogether. Fogs, snowstorms, pesticides and the destruction of stop-over feeding sites kill many birds. Yet the birds have to risk migration. Winter in Europe is a season of shortages of food and shelter and most birds use up their energy seeking a place where food is plentiful to prepare their bodies for the next breeding season. So the birds follow the sun, the season of summer and food supplies. Swallows that do not migrate always die during the harsh European winter.

The value of bird rings

Bird watchers and ornithologists catch many live birds each year. They put a bird ring around the bird's leg and then let the bird go. This ring is light and has a number on it. Each number is different and is recorded with details of the bird. This will help ornithologists to track and study the history of each bird when the ring is found.
If you find one of these rings on a dead bird, flatten the ring and attach it to a card along with this information: the date, the place, what you saw of the dead bird and the ring number.

Post the ring and this information to:

SAFRING
University of Cape Town
Rondebosch 7701



Your information will help ornithologists with their research into the behaviour of birds. For example, this research has helped us understand the patterns of bird migration. In fact, almost everything you have learnt in this module has come from information provided from records from bird rings!

University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

latitude	The seasonal travelling of birds to avoid winter
longitude	Positions east or west of Greenwich Observatory in London
migration	
ornithologist	A scientist who studies birds and their behaviour
	Positions north or south of the equator

WHAT I HAVE LEARNT about the tools of science

Ornithologists (scientists who study birds) make careful observations of the movement and behaviour of birds to enable them to control pests and reduce, where possible, threats to endangered bird species. This work is not based on love, guesses or good ideas... but on the careful analysis of field data collected by thousands of bird lovers everywhere. A ring collected recently told SAFRING that the stork that wore it was 30 years old and could have flown 400 000 kilmetres to feed and breed in those years!

University of Cape Town

5.4 THE CHICKEN AND THE EGG

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Evaluate the ethics of the Great Ostrich - Diamond Rush.
2. See and understand the growth of a young bird inside its egg shell.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Scientific knowledge helping us to manage our natural resources.
NS-SO1 Using process skills to investigate a natural phenomenon.
NS-SO8 Science is a values related endeavour involving ethical issues.
NS-SO9 Science affects our life quality.
LLC-SO2 Showing critical awareness of language usage in scientific context.
T-SO1 / NS-SO3 Applying the technological process to a design problem.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Evaluate the ethics of the Great Ostrich - Diamond Rush.
2. See and understand the growth of a young bird inside its eggshell.

The fortune-making birds



Far in the lonely wastes of the Namib Desert near Walvis Bay, a hunter made a discovery that would revolutionise the diamond mining industry overnight in southern Africa. He had shot a wild ostrich for meat. He cut open the bird's gizzard (where ostriches keep stones they have swallowed to grind food) and he found himself staring at an amazing, indestructible diamond shining in the sunshine! The news travelled south fast from the bars of Walvis Bay to the diamond diggings along the coast near the Orange River mouth. There are diamonds in the ostriches!

It is known that all birds lack teeth and swallow stones and grit to help them grind up the hard food they eat. Ostriches, especially, swallow all sorts of bright, hard things to help them grind their food - and these include metal and broken glass. The ostrich can walk the deserts for up to three months without water. In Namibia, ostriches ranged freely over the prohibited area of gravels containing diamonds called the Sperregebiet, without a prospecting permit...

People began to realise that the ostrich was a natural diamond sorter and collector. In fact, here was a smuggler beyond suspicion! The Walvis Bay hunter had discovered this on the lonely coast where diamonds lie exposed on the sands one day and are covered up by sands the next day. How many diamonds could an ostrich swallow? There was only one way to find out!

Prospectors abandoned their panning and sieving, bought rifles and joined the Great Ostrich Hunt. Over 12 000 desert ostriches were killed and their skins exported through Walvis Bay. And there *were* some gizzards full of treasure. One shot bird had 53 diamonds inside it! The desert birds were almost hunted out of existence. The last few survivors wisely abandoned the area for the less accessible interior deserts of southern Africa. The disappointed miners returned to their diggings and the harder way of finding the glittering stones of fortune.

Adapted from ***Ostrich Country***, F. Golding and ***Lords of the Last Frontier***, L.G. Green.

Read this story.

- Design a newspaper article for the ***Walvis Bay Chronicle*** or the ***Diggers Journal.***
- Rewrite the story of the ostrich hunt in your own words. Try to capture the excitement that the discovery meant for the local people in desert towns. Or you can critically explore the ethical issues involved in this hunting of ostriches.

University of Cape Town

The biggest egg of all

Ostrich eggs

One ostrich egg weighs about 1,5 kg. That is equivalent to about 24 hen's eggs!

The ostrich is the world's largest flightless bird and lays the biggest egg. Despite the fact that they cannot fly and lay their large cream coloured, food-filled, un-camouflaged eggs on the ground in open places, they survive. Ostriches have a reputation for ignoring threats of danger by hiding their heads in the sand. But ostriches have a strong sense of survival. Ostriches have many natural enemies in the wild, such as baboons, hyenas, jackal, lion, leopard, cheetah and bush pigs. The ostrich lived in southern Africa long before humans arrived here.



In your groups:

- Discuss how ostriches might care for their young before you read further.

Now study this information and use it to answer the question below.

1. The giant eggs of ostriches are full of instant food (each one weighs about 1,5 kg or about 24 hen's eggs).

2. Ostriches take six weeks to hatch their chicks once they start to incubate the eggs.

3. The cock bird sits on the eggs at night and the hen bird takes over during the day.

4. They have long strong kicking legs and a very strong toenail that can punch through a sheet of corrugated iron!

5. They can run across the veld faster than horses.

6. They are aggressive birds. The male ostrich (cock) will not hesitate to attack anything that may threaten them in the breeding season.

7. If the grass-camouflaged, speckled chicks are attacked by a predator too large for the cock bird to drive off, the chicks will scatter and disappear into the grass. They lie down with their heads held low. The cock and hen lead the predator away by pretending to have a broken leg before disappearing into the distance. Once the ruse has worked, the confused predator leaves with empty jaws.

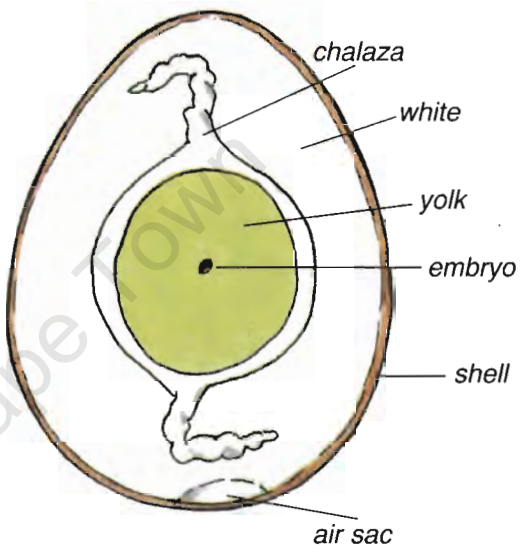
- How do you think all these factors ensure the survival of the young ostriches?

University of Cape Town

EXPLORING SCIENCE EGGS - DESIGNS FOR LIFE

Eggs are special designs for living.
Before you start this activity, think about the advantages that a bird has over an animal that produces its young live from within its own body like a dog or cat.
Are there any disadvantages? Report you findings to the class.

1. Examine an egg. Try to answer these questions through your own knowledge without cracking the egg open!
   - How can you tell if this egg is fresh or not?
     There is an air sac at one end of the shell.
   - Which end?
   - What is the use of this air sac?
   - Is an egg shell porous or not? How can you find out?
2. Carefully crack your egg over a saucer.
   Try to separate the yolk from the clear (white) of the egg so that the yolk remains in one half of the shell.
   - Is there any clear jelly (chalaza) hanging on the yolk sac at either end? What is the purpose of the chalaza in the egg?
   - What part of this egg will become the chicken if it is fertilised?
   - What lines the shell? What is the purpose of the lining?



Inside an egg

The egg farmer and the hen

There are many different ways of looking after poultry. Some of you may have kept hens at home or have visited a home or farm where chickens are kept in open runs.

Answer the questions below by choosing the correct answer from the lists given:

- What do hens need every day?
  (Earthworms; insects; seeds; vegetables; shell grit; water.)
- What happens to the eggs if the hens don't get enough calcium?
  (Less eggs are laid; shells are thin and break easily; eggs may be laid without shells.)
- When the hen becomes broody and starts to incubate her eggs, does she leave the nest before the chicks hatch out?
  (The hen leaves to feed; the hen never leaves the eggs; the cock sits on the eggs.)
- The eggs are laid one a day, but do the chicks all hatch out on the same day?
  (They hatch out one a day; the hen doesn't start to incubate her eggs until she has about ten eggs.)
- If the eggs get too cold they will die. (True; false.)
- The eggs we buy in the shops will not produce chickens because...
  (the eggs were not fertilised by a cockerel before laying; the embryos died when the eggs were taken away from the hen; the eggs have been stored in a fridge.)

University of Cape Town

EXPLORING SCIENCE — WINDOW THROUGH A SHELL

The pictures on this page show what happens in a fertilised egg during various stages of incubation. These pictures show the development of the chick over a three week period.



1. The newly laid fertilised egg

1. In this egg a tiny invisible speck lies on the yolk sac. It is the fertilised embryo and it is growing rapidly, feeding on the yolk.
   - Is the embryo alive or dead?
   - Is it a chicken or something else that is too small to see?

2. What do you think this black spot is? Look at the next picture to see what it will become. The chicken body is almost all blood vessels.
   - Why are blood vessels important?



2. The growing embryo in the egg



3. The newly formed chick inside the egg

3. How does this chicken breathe?
   - What has happened to its food supply?
   - Why do you think the head end seems to develop faster than the rest of the bird?

The sac on the inside of the shell has been removed to see the chicken.
   - What is the use of the sac?

During incubation the hen turns the eggs over every few hours.
   - Why do you think the hen does this?



4. The chicken breaks the shell

4. How does a chicken manage to cut its shell open from the inside?
   - What would it have to do first? Why?
   - What would be the next obvious thing to do?



5. The chicken has just hatched!

5. Why is the chick lying still like this?
   - Why does it have such large feet and so many feathers already ?
   - How will it keep warm and safe?
   - Where will its food come from now?

University of Cape Town

EXPLORING SCIENCE FOWL PLAY

For this investigation, your group will be assigned a chick to care for in class for three weeks.

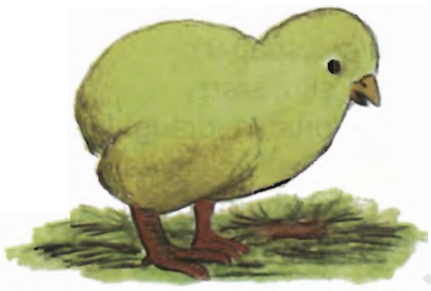


The day old chick

1. Design and build a cage that will keep the chicks alive and healthy until you are ready to give them away.

The cage must:
- be warmed to about 37°C. Chicks die easily and need to be kept warm continuously.
- be safely and sturdily constructed.
- be cleaned daily with a supply of clean, fresh food and water.

2. Study the chicks as they grow.
   Use a sensitive kitchen scale to measure the weight of your bird every week.
   Draw a graph to show the increase in weight over time.
   Estimate how heavy your bird will be after six weeks.
   Record the outward changes in your bird that you see each week.



After three weeks, you will need to sell them to a farmer or place them in a larger run.
Calculate what your material, food and electricity costs were when calculating the price of the young birds for sale.
Broiler chickens grow fast enough to eat within six weeks.
Check the price of chicken per kilogram in a local shop.

University of Cape Town

WHAT I HAVE LEARNT about caring for poutry

Match these questions to the answers listed:

1. When the hen starts incubating eggs, we say she is _____. (broody; hatching)
2. The hen tries to collect about _____ eggs before she starts sitting on them. (5; 10; 15; 20; 25)
3. The hen sits on the eggs to _____. (shade them; keep them warm; protect them; hide them)
4. Young chicks need _____ and _____. (hen's milk; growing mash; seeds and worms; shell grit; water)
5. Chicks cannot fly for several weeks because _____. (they have no feathers; they have no quill feathers; their wings are too short)
6. A chicken is usually eaten before is first birthday. (True / false)

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

broiler	A young fowl bred for meat alone
broody	The large feathers of the wing and tail
chalaza	The chicken emerging from the egg
embryo	The hen sitting to incubate the eggs
fertilised egg	The protein balancers holding the yolk
hatching	The first food of the embryo in the centre of the egg
incubation	An egg in which an embryo has formed
quill feathers	Warming the egg to best growth temperature
yolk	The young bird living in the shell

WHAT I HAVE LEARNT about ethics and the tools of science

Scientists deal with ethical issues. Science can give us the tools to do things but we do not have the right to do what we like, in the name of science. Battery poultry farmers keep hens in very tiny cages (the size of a single sheet of newspaper). The birds are kept under continuous electric light and never see the sun, stars, a blade of grass or an insect. The chickens sit and stand on uncomfortable, draughty wire grids all their lives to make the cage easier to clean, to make egg collecting easy, and to prevent them wasting food energy by walking about. This helps them to produce more and cheaper eggs! There are many birds in each of these cages, and thousands of cages in a battery.

To prevent the irritable, bored birds from pecking each other in these crowded conditions, farmers often cut off the ends of their beaks. These chickens cannot sit, flap, hatch eggs, walk about or peck! The battery is an egg factory where the laying machines are all life prisoners. This is the real cost of cheaper eggs. This is why some shoppers prefer to buy free-range eggs, even though they cost a bit more. Some people refuse to eat eggs, chicken or perhaps any animal products at all for this sort of reason. Science and ethics are never separate issues.

Poultry science has devised this efficient method of getting hens to produce more eggs, but is it a humane way of treating any animal? What about the rights of animals? Many shoppers and consumers prefer not to think about this.

University of Cape Town

6.1 MOVING IN AIR AND WATER

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain why moving fluids produce frictional force.
2. Describe and explain the effect of the size of the leading edge of an object on frictional force.
3. Describe and explain the effect of the stickiness of a fluid on frictional force.
4. Explain terminal speed and the factors which determine its value.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.
NS-SO5 Using scientific knowledge and skills to support responsible decision making

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify the factors which cause resistance to movement (drag) in fluids.
2. Explain how the area an object's leading edge and the viscosity of fluids affects the frictional force.
3. Design an object which will experience minimum drag in a fluid.
4. Develop a reasoned argument and defend the design of your object.

The last race



Gliding in a wide circle high above the plains of Africa, the peregrine falcon watched the world below. It was that quiet time of late morning when sky-wise birds rest on leafy perches that cannot be seen from above. It was almost quiet, except for the rapid beating of the racing pigeon's wings and heart as it flew between the flat topped hills of the old Karoo, finding the shortest way back to its pigeon loft in the west. It was the strongest bird in the flock. After an hour of flying, it had left the rest well behind. The sharp eyes of the hunter above watched the tiny grey speck as the pigeon moved swiftly across the wide open spaces below.

The falcon had seen the pigeon over three kilometres away. Now, rolling effortlessly out of the wide circle, the falcon folded its wings and dropped like a stone. Flying fast, wind roaring past his ears and tugging at his feathers, he bore down on the pigeon.

The pigeon wanted to reach its home loft 300 kilometres away. It gave no thought to a killer diving out of the sky.

The falcon had not missed a kill since maturing. He was born to live on the winds, a high speed flyer. He folded his wings back to reduce the air drag to almost nothing.

The startled pigeon realised something was wrong... but it was too late! Flashing in from above at 270 kilometres an hour, the falcon slammed its extended talons into its prey. A cloud of pigeon feathers burst from the centre of impact. The pigeon's heart stopped. It heard nothing. The shock of that impact had killed it.

The falcon locked its talons inside the limp body. It extended its wings to act as air brakes, curved out of the death dive, corrected for the extra load and effortlessly flapped away over the barren hills. It settled, feather light, on a craggy ledge in the Swartberg mountains. Its efficient curved beak tore into the soft, warm body. The champion pigeon had lost the race after all!

University of Cape Town

Read this story and answer these questions in your groups:

- How is the falcon's body adapted to moving at high speeds through air?
- How does it feel when air tugs at you? (For example, when you are cycling or walking into a strong head wind.) What can you lessen the tug?

Living in air and water

Most living creatures live surrounded by air or by water. Land animals move through the air. Trees flex and bend when winds move around them. In water, fish swim against the current and reeds in the river move and rustle with the flow of the water.

Let's explore how animals **move** in water and air (fluids).
Gases (such as air) and liquids (such as water) are called **fluids**.
Fluids can flow from one place to another when a force acts on them. Fluids flow around objects like animals and plants. When any object moves through a fluid, it has to push fluid particles apart. If the **cohesive force** attracting the particles towards each other is large, it will be difficult to push through the fluid.
The fluid will rub against the surface of the object.

If the **adhesive force** between the fluid and the particles in the surface of the penetrating object is large, the fluid particles will stick to the surface of the object and drag other fluid particles with them. This will cause the moving object to experience extra resistance (or **drag**) that will slow it down.

An object that is standing still in a moving fluid will experience a force which will try to drag it in the direction of the fluid's movement.
This force is called **friction**.
The force of friction is always in the opposite direction of the motion.
Imagine being in water up to your waist and then trying to run. It will be difficult because the water exerts a large frictional force you as you move.



We warm our hands on a cold morning by rubbing them together.
When the surfaces of objects rub against each other, they experience a **frictional force.**
When there is friction, energy is transferred. San wanderers in Africa used to start fires by spinning a stick-drill with a bow in dry grass and blowing the smoking embers into a flame. Friction causes objects to heat up.
Things which move very fast through the atmosphere also get very warm.
Have you ever seen a shooting star? It is a small meteorite that burns up in the denser atmosphere through friction with air.

In your groups, discuss the following:

- What is the difference between cohesive and adhesive forces?
- How does the size of cohesive forces in gases compare with those in liquids?
- List some properties of liquids and gases to support your answer above. (Look at module 2.1 again - **What we know about liquids and gases**.)
- What is the main difference between gases and liquids?
- Why can't solids flow?

University of Cape Town

EXPLORING SCIENCE PUSHING FLUID PARTICLES APART

Let's explore how the resistance of a fluid affects the movement on the front end of a moving object.
You will need:
an A4 size piece of paper and a large flat piece of cardboard.

1. Hold the page by two corners so that it hangs downwards. Drop the page.
   Describe how it falls.



2. Now hold the page so that it is parallel to the floor. Drop it again.
   - Did it fall faster this time?

3. Crumple the paper into a little ball. Drop it.
   - How fast did it fall now?
     Compare this speed to the other times you dropped the paper.



4. Now answer these questions:
   - Did the weight of the paper change at all?
   - Think about the area of the front end of the falling paper in all three cases.
   - Explain the reason for the differences between the speeds with which the paper moved through air.

5. Now go outside. Hold the cardboard in front of you with its thin edge facing forwards.
   Run as fast as you can.
   - Can you feel the air pushing against the cardboard?



6. Now hold the cardboard so that its flat edge is in front of you. Walk slowly.
   - Can you feel the air pushing against the cardboard?

7. Now run as fast as you can with the cardboard flat in front of you.
   - Can you feel the air pushing against the cardboard now?

Explain any differences in the resistance you experience between the two cardboard positions; and the two speeds for the cardboard when it was held flat.

University of Cape Town

Saved by friction

In the last investigation we found that **air resistance** or **friction** increases with speed. The faster an object moves through a fluid, the more fluid particles it meets with and the greater the friction becomes. When an object falls through a fluid, its speed increases.

As its speed increases the **frictional force** increases. If an object falls far enough, the frictional force becomes as large as the object's weight.
At this stage, the object's speed becomes constant, i.e. its speed does not increase any more. This constant speed is called its **terminal speed**.
Heavier, or denser, objects have greater terminal speeds as they have to move faster before frictional force is equal to their weight.



A man falling freely through the air has a terminal speed of about 200 kilometres per hour.
We can reduce this terminal speed by enlarging the area which has to move through the air.

Parachutists land safely because they have been successful in reducing their terminal speed to about 10 kilometres per hour, by increasing friction.

In water, small planktonic animals often have long legs, long bristles, large feathery gills or antennae to enlarge their surfaces to slow down their sinking in the sea.



Discuss the following in your groups:

- Look at the picture of the parachutist and explain the function of the parachute.
- Explain why ants or small spiders can fall from large heights and not be injured when they land on the ground.

University of Cape Town

EXPLORING SCIENCE PUSHING FLUID PARTICLES APART

Let's explore the effects of the thickness or stickiness in a fluid.
You will need:

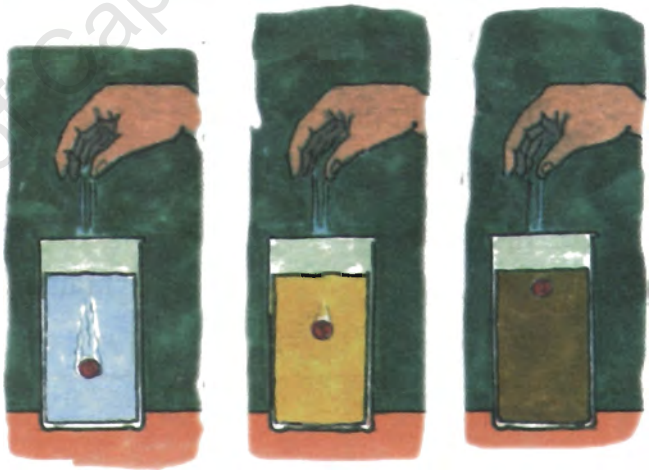
three containers (small plastic cool drink bottles with their tops cut off),
a small flat stick (sucker stick), water,
cooking oil and engine lubricating oil
and three marbles.

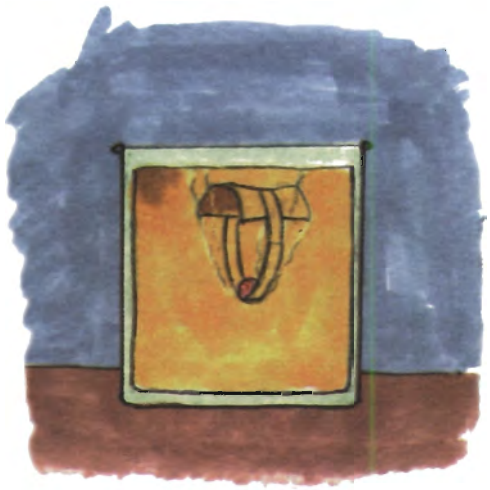
1. Slowly pour each of the three liquids into the three different containers until they are half-full.
   - Which liquid flows easiest?
   - Which liquid is the most sticky?
   - Which liquid has the greatest cohesive forces?

2. Stir the stick quickly through each of the liquids.
   Hold the stick edge on and then flat when you stir.
   - In which one of these two positions does the stick experience the greatest resistance? Explain why.

3. Now fill the containers almost to the top with the liquids.

4. You are now going to drop marbles into the liquids.
   Place the three containers next to each other. Drop a marble into each of the liquids from the same height and at the same time.
   - Which marble reached the bottom first?
   - Which marble reached the bottom last?
   - How do the results relate to the stickiness (or viscosity) of each liquid?
   - Explain what happened.





5. We can observe the terminal speed of a marble falling in oil by making a parachute for the marble by using sticky tape and paper.
   Drop the marble with its parachute into the container of lubricating oil, as shown in the picture.
   - Describe the motion of the marble as it sinks.

University of Cape Town

WHAT I HAVE LEARNT about moving through air and water

Are these statements true or false?

1. Particles of a fluid can slide over each other.
2. The shape of an object does not affect the resistance it experiences when moving in a fluid.
3. Terminal speed refers to the maximum speed reached by an object which falls in a fluid.
4. Objects fall faster in stickier liquids.

Challenge:
As a group, design a shape which you think will reach the highest speed if it was allowed to fall in oil.
Design a shape to generate the least friction in falling through a fluid.

Remember these new ideas

We have learnt some new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

fluid	A force which opposes motion
friction	The highest speed which an object which is falling in a fluid can reach
terminal speed	The resistance to movement through a fluid
adhesive forces	Attraction between different substances
drag	Matter which can flow

University of Cape Town

6.2 SLIPPING THROUGH WATER AND AIR

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain how turbulence is produced in a fluid.
2. Explain how eddies are produced in a fluid.
3. Explain why turbulence and eddies slow down objects moving through fluids.
4. Explain how to steamline an object.
5. Explain how resistance to movement (drag) is produced or reduced by different shapes.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.
NS-SO5 Using scientific knowledge and skills to support responsible decision making.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Demonstrate an understanding of the formation of turbulence.
2. Explain the formation of eddies.
3. Explain why turbulence and eddies lead to an increase in friction.
4. Explain why streamlined shapes produce similar results in oil.

A flying start

It starts with a toe-touch and ends with the ultimate in dolphin behaviour: a mighty thrust by the animal which propels its trainer out of the water and into the air like the swoosh of a rocket. This power jump demands split-second timing and total trust between the trainer and dolphin. Charmaine starts by duck-diving down to a marked target - a smiling face on the floor of the pool - closely followed by the dolphin. She then stiffens her body to streamline it and the dolphin has been trained to shoot her straight out of the water by putting its nose on the ball of one of her feet.

"You cannot miss the target otherwise you will splat on the side of the pool", Charmaine says. "I am normally terrified of heights. It is worse than the Big Dipper. Your stomach gets left behind!"

This sequence is now being perfected at the dolphinarium to enable it to be a regular feature of the daily shows. Afrika, the three-year-old dolphin, weighs 200 kilograms and was born in captivity. She is the fastest learner among the dolphins currently being trained, and this week showed off her winning style.

Adapted from ***Sunday Argus*** *3/5/1998.*



University of Cape Town

Study the picture above and answer the following questions:

- How high is the trainer in the air?
- How does she get that high?
- Could she get that high if she was not moving very fast under the water?
- Is it easy to move fast in water?

EXPLORING SCIENCE WHEN FLUIDS BECOME TURBULENT

We saw how objects which move through a fluid experience resistance (friction) to their motion. We also explored some of the factors which determine the size of the force of fluid friction.

How is it possible for the dolphin in the story to move so fast through the water in the tiny tank? Let's find out.

For this investigation you will need:
a length of string,
a large pot or a bucket,
some food colouring,
and a wooden spoon.



1. Firstly, light the string and then blow out the flame so that the string smokes.
   - Describe the movement of the smoke.

2. Now fill the container with water. Add some food colouring. Hold the wooden spoon vertically in the water and stir it quickly through the water with its thin side as the leading edge .
   - Describe the motion of the water around the spoon.



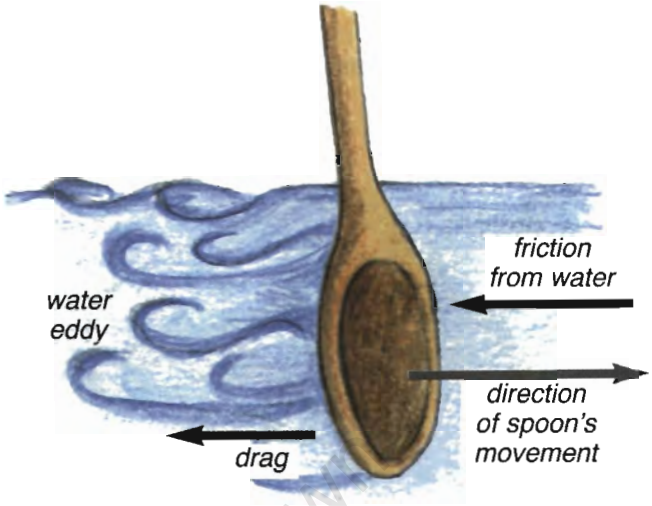
3. Repeat the action, but now hold the spoon at an angle to the direction of motion in the water. Increase the angle until the wide side of the spoon is held at right angles to the direction of motion in the water.
   - Describe the motion of the water passing the spoon.
   - In which case is most resistance experienced?

University of Cape Town

Rowing is hard work!

In the last investigation we saw how smoke rises. At first the smoke rises smoothly, but then it suddenly begins to twist about. This region of disorder is known as **turbulence**. The smoothly rising air has become turbulent.

We also saw that the same thing happens when the spoon in the water is held at an angle. We felt that the greatest resistance to motion in the water is experienced when the greatest turbulence is produced.
But why does the water become turbulent behind the spoon?
When the spoon is moved forward through the water there is friction between the spoon and the water.
This friction causes the water to spin as it moves in behind the spoon. This spinning or turbulent water is called an **eddy**.



Turbulence occurs in the water behind the spoon as it is pulled through water

The water moves because energy has been transferred from the moving spoon to the water, and the water has more 'moving' energy. If you stop pushing the spoon in the water, the water would slow down. The more turbulent the water becomes, the more energy has been transferred from the spoon.
The spoon is difficult to push fast through the water because all its energy is going into the motion of the water.

In your groups:

- Explain what happens when a rower rows a boat through the water using wooden oars. Use the ideas above to help to explain the process.



Eddies behind the oars

When a boat is rowed through water, the water tugs on it. The oars and the boat experience a resistence to movement.
The water that comes into contact with the hull of the boat starts to spin and eddies form. Water that was still begins to move more quickly as energy is transferred from the boat to the water. The more quickly the boat moves, the more quickly the water spins and becomes turbulent.

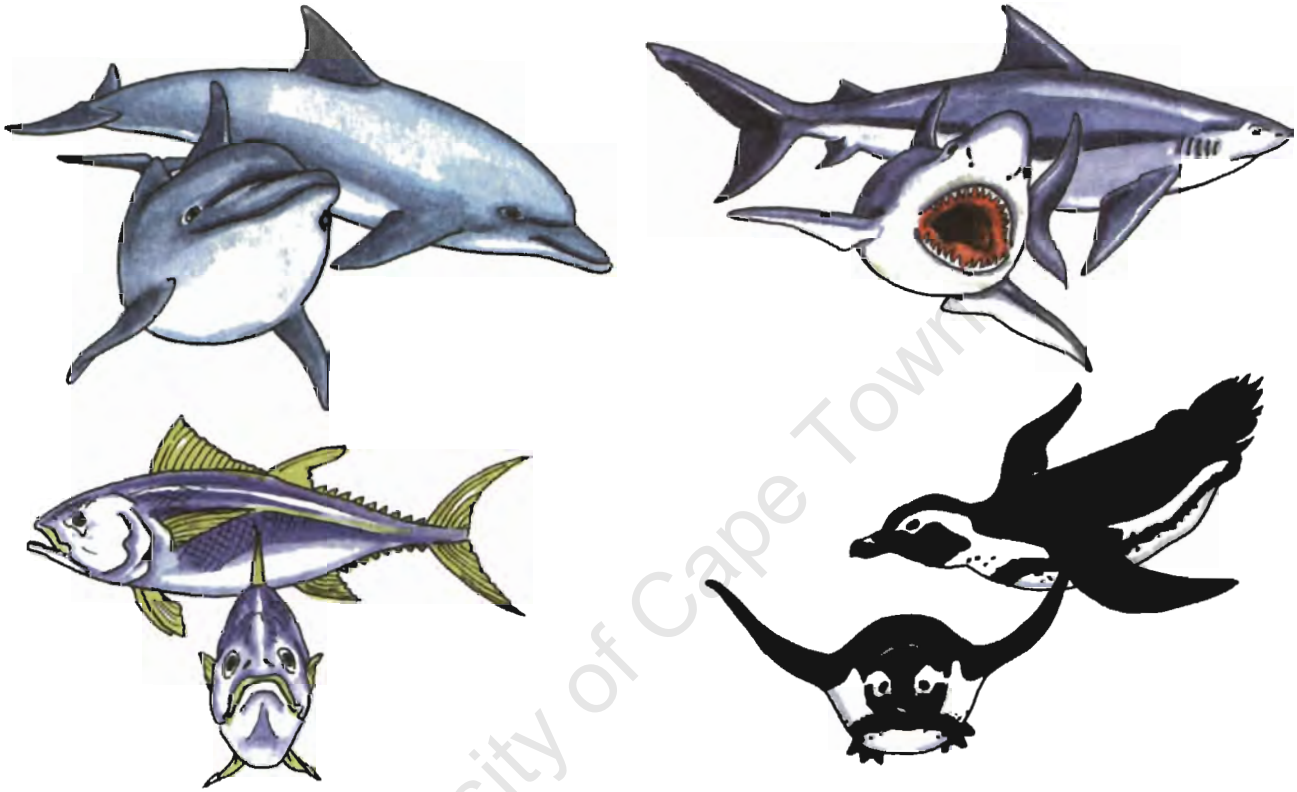
This resistance to motion makes rowing such hard work! To reduce resistance to motion in water, we have to somehow reduce turbulence and eddies.
Ships, cars and aeroplanes use extra fuel to help them overcome the resistance to motion.

- How do you think this resistance can be reduced further?

University of Cape Town

EXPLORING SCIENCE REDUCING TURBULENCE AND EDDIES

Many water animals seem to move about without much effort in water. Water is about 800 times "thicker" than air. Animals which move through water experience resistance to their motion because of turbulence and eddy formation. Yet, these animals can move very fast through the water.



University of Cape Town

Look at these illustrations above and think about how these animals are shaped to move quickly and smoothly through water.

In this investigation, we can study how the shape of an object can help it to move through water with less resistance.



You will need:

plasticine (modelling clay),
a flat dish filled with lubricating oil
and a deep container filled with lubricating oil.

1. Make a cylinder out of plasticine.
   The diameter of the widest part of the cylinder should be about two centimetres.
   - How much plasticine you have used? Measure its weight.

2. Now use the same weight of plasticine to make these shapes shown in the picture.
   - How are these shapes different from the cylinder you made first?





3. Now fix the shapes to a piece of wire.
   You are going to drag your shapes through the oil in the tray and look for the formation of turbulence and eddy patterns.

   - Half submerge the object in oil and pull it fairly fast in the direction shown.
   - How does the oil flow around each of the different shapes you made?

4. Now we are now going to make these objects fall through a column of lubricating oil to get an idea of how easy it is for them to travel in oil.

   We want to find which shape experiences least resistance. To do this, we need to try to reduce the resistance to their motion as much as possible.

   - How does the shape of the object reduce resistance to motion through air?
   - Why have we kept the weight of the objects about the same?
   - Predict which shape should experience the least resistance in oil.



   Drop all the shapes into the oil and release them together at the same time.
   - Which shape falls to the bottom first?

   Repeat this experiment a number of times to make sure that everyone can see what is happening.

University of Cape Town

Designed for moving

We saw how the complete spindle shape moves most easily through the oil.
Is this the shape of the animals we looked at? Shapes which offer little resistance to motion in fluids are said to be **streamlined**.



The 'nose end' (front end) reduces the area of fluid which can push against the moving object. The 'tail end' or back end reduces the amount of turbulence created when the object moves through the fluid.

Racing cyclists and down-hill ski racers try to move through the air quickly to reduce the resistance to their motion as much as possible.

- What can also help these racers to reduce resistance to motion through the air?

Canoes also use the spindle shape to reduce resistance to forward movement.

University of Cape Town

Remember these new ideas

We have learnt some new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

turbulence	Spinning or rotating currents in a fluid
eddies	The shape of an object which reduces fluid friction to a minimum
streamlined	Disorder in the flow of a fluid

WHAT I HAVE LEARNT about the tools of science

Scientists know that living organisms also have designs for reducing resistance (drag) to their motion. Many people believe that the shapes of many animals that are alive today have developed and evolved over millions of years to make it easier for them to move in fluids. Scientists look at the way the problems of motion are solved in nature and try to apply these solutions to our own problems of moving through fluids.

6.3 RISING ON WINGS

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain Bernoulli's idea.
2. Predict and explain why a kicked spinning ball will curve on a windless day.
3. Demonstrate an understanding of lift caused by an aerofoil shape.
4. Predict the movement of objects in fluids using Bernoulli's ideas.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Demonstrate an understanding of the Bernoulli effect.
2. Predict the flight of a kicked soccer ball on a windless day.
3. Demonstrate an understanding of lift caused by an aerofoil shape.
4. Predict the movement of objects in fluids.

When storm winds blow



It had been a perfect day. Just the slightest hint of a north westerly wind, but, for mid-winter, it had been pleasant. It was hard to believe that the weather report had predicted a storm for half an hour's time. Well, they were right!

Within half an hour the wind speeds increased to over one hundred kilometres per hour. Wild winds tore whole trees apart, branches off. Power lines came down too, trapping people in their homes. Some lucky children missed school because of the danger of electrocution.

Inside the house, I thought my roof was going to lift off, the wind was tugging at it so fiercely. Every time a stronger gust of wind came along, I found that my eardrums were being sucked outwards, as the pressure in the house fell. Air was being sucked out of my house. There were sudden pressure drops outside when the wind gusted past.

The real danger was not that my roof might be sucked off, but rather that it might be popped off by the higher air pressure inside the house at these times. Once I knew what the danger was, I realised that I should open some windows on the side away from the wind, so that high pressure air could escape more easily. It was colder after that, but much less scary and the roof of my little house survived. But why did the pressure outside drop when the wind gusted like that? Join me as I find out.

Read this story and discuss the following questions in your groups:

- Have you ever been in a house when a very strong wind was blowing? Describe your experience.
- Which part of a house is usually damaged by strong winds?
- Why will a well-ventilated house probably not lose its roof in a storm?

EXPLORING SCIENCE AIRSTREAMS OVER OBJECTS

In this investigation, we will investigate how moving air affects objects.

For this investigation you will need:
some sheets of paper,
a ping-pong ball,
a plastic cooldrink bottle and a teaspoon.



1. Hold two sheets of paper a few centimetres apart.
   - What do you think will happen if you blow hard between the sheets?

   Now blow down hard between the sheets.
   - What happened?
   - Is this what you thought would happen?
   - Try to explain any differences.



2. Fold a sheet of paper into a tunnel. Place it near the edge of a desk or table as shown in the picture.
   You are going to blow into and through the tunnel.
   - What do you think will happen to the tunnel?
   - Why do you think this may happen?

   Now, hold your mouth close to the table and blow hard through the tunnel.
   - What happened?
   - Is this what you thought would happen?

   Try to explain any differences.

3. Place your hand on a sheet of paper.
   Hold the paper near your mouth.
   You are going to blow **hard** between your fingers and then release the paper while doing so.
   - What do you think will happen to the sheet of paper?

   Now blow hard between your fingers and let go of the paper while blowing.
   - What happened?
   - Is this what you thought would happen?
   - Try to explain any differences.

University of Cape Town



4. Hold a piece of paper so that its edge touches your chin just below your lower lip.
   You are going to blow hard across the paper.
   - What do you think will happen to the sheet of paper?

   Now blow hard over the paper.
   - What happened?
   - Is this what you thought would happen?
   - Try to explain any differences.

5. Place the ping-pong ball in a funnel or the top half of a cool drink bottle.
   You are going to attempt to blow the ball into the air by blowing through the narrow end of the funnel.
   - What do you think will happen to the ping-pong ball?

Bernoulli's answer

We found that the sheets of paper behave as if they are pushed towards or pulled towards the side over which we blew.
- Why do you think that happened?



Daniel Bernoulli, a Swiss scientist, was interested in this as well. He discovered that when the **speed** of a fluid **increases**, the **pressure** it exerts becomes **less**.

When we hold a sheet of paper in our hand, air is at rest on both sides of the paper. The pressure exerted on the two sides of the paper by the air is the same. When we blow across the paper, it moves *towards* the side we are blowing on. Why?

Along one side of the paper, air is moving fast; while the air on the other side it is at rest. According to Bernoulli, the pressure exerted by the fast moving air is less than that exerted by the stationary air. The paper is pushed in the direction of the lower pressure.

In the previous investigation, air moved fast on one side of a sheet of paper while on the other side the air was at rest.
The pressure exerted by the fast moving air is **lower** than the pressure exerted by the air at rest.
So the force pushing on the side in contact with the fast moving air is **less** than the force pushing on the other side.
The paper is pushed towards the side with the faster moving air.

University of Cape Town

WHAT I HAVE LEARNT about Bernoulli's idea

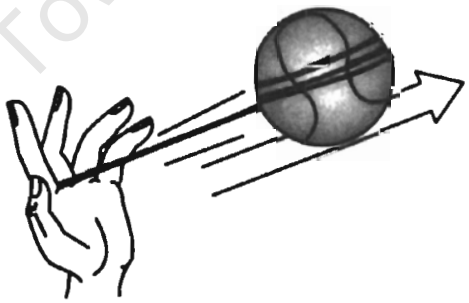
Go back to the last investigation.
Try to describe what is happening in each case as if you were Daniel Bernoulli.

EXPLORING SCIENCE BERNOULLI AND SPORT

In this investigation, we will put Bernoulli's idea into practise.

You will need:
a tennis ball,
a short length of ribbon or strong fabric tape.

1. Tie the ribbon around your middle finger.
Wrap the free end around a tennis ball three times.
For this investigation, you will throw the ball with the ribbon wrapped around it.
The direction you wrap the ribbon and the way you throw it will make the ball spin in a particular way when it is thrown.
Try three different throws with the ribbon tied in different ways each time.

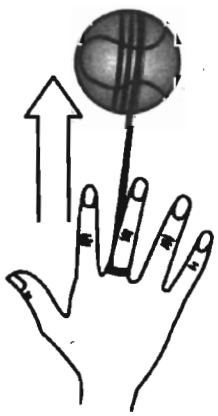


Wrapping the ribbon around the ball and throwing it underhand

2. Take note of each of the directions you wrap the ribbon on the tennis ball before you throw it.
- Which way do you think the ball will spin?
Make a drawing of it before you throw the ball.

3. Each time you throw the ball, note the following:
- What happened in each case?

Draw the path of the ball on your sketches.
- Is this what you thought would happen?

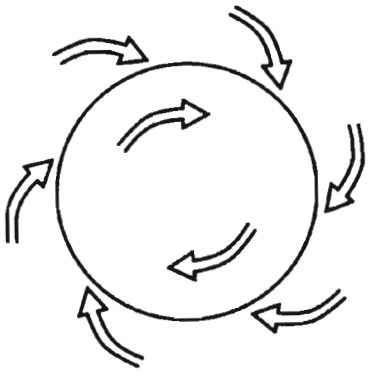


Wrapping the ribbon around the ball and throwing it overhand

University of Cape Town

Why spinning soccer balls curve

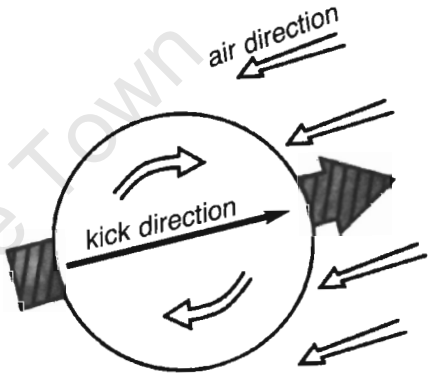
When an object, like a soccer ball, is placed in a fluid (like air) a layer of particles sticks to its surface. When the ball moves in the air, this air layer (the boundary layer) will pull other layers of the air along with it. The ball experiences **frictional drag**.



Spinning ball

If a kicked soccer ball spins through the air, one side will be moving **against the direction** in which air is moving past the ball. This causes this side of the ball to slow down because of the frictional drag.

On the other side of the ball, air moves **in the direction** that air is moving past the ball. This layer of air speeds up. Fast moving air exerts less pressure than slow moving air. The ball is pushed in the direction of the faster moving air, i.e. the ball swings in the direction in which it is spinning. Soccer players choose the way the ball will curve in flight by putting a spin on the ball when they kick it.



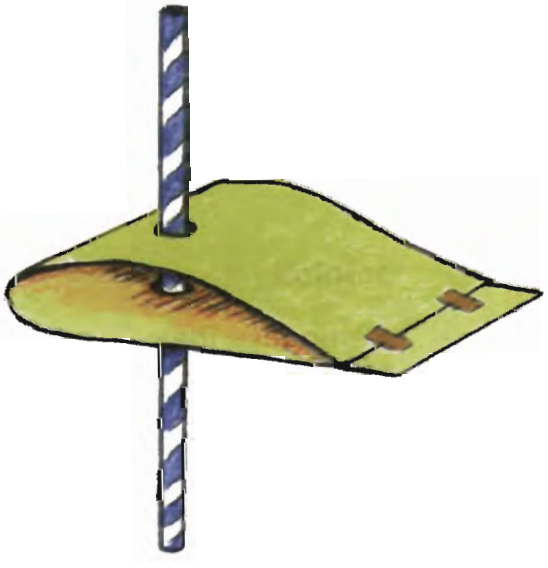
They are using Bernoulli's idea without knowing it!

University of Cape Town

EXPLORING SCIENCE BERNOULLI AND FLYING

Let's make a paper wing.

You will need:
a piece of A4 paper, a straw,
some string and sticky tape.



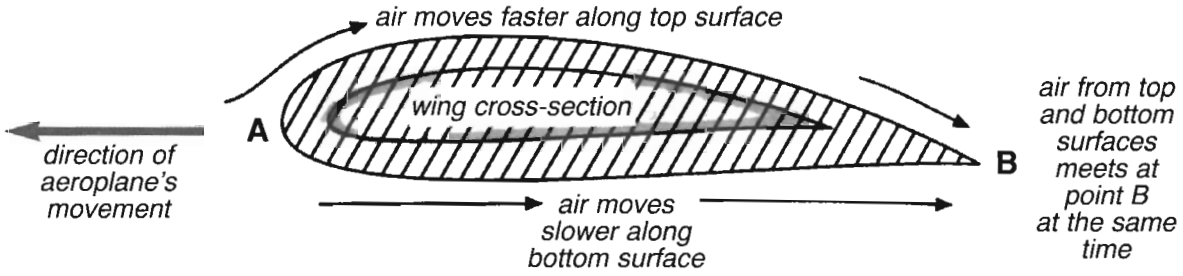
1. Fold a piece of A4 paper in half. Push the top half towards the fold and stick it to the bottom half with sticky tape, as shown in the illustration.

2. Cut holes opposite each other in both the top and bottom surfaces and push a drinking straw through the holes. Tape the straw to the wing.

3. Push a length of string through the straw, pull it tight and hold the wing in front of your mouth Blow fairly hard over the wing.
   - What happened to the wing?

Why aerofoil-shaped wings create lift in air

Aeroplane wings are not flat.
A cross-section through a wing looks like a tear drop which has been cut in half.
Wings have at least one curved surface.



How air travels over the surfaces of a wing

The distance between points A and B along the curved top surface is longer than the distance along the straighter bottom surface.
As air moves over the top of the wing it has to travel a longer distance than along the lower surface. It speeds up along the top surface.
The air moving along the bottom surface moves slower but arrives at the back of the wing (point B) **at the same time** as the top air current.
The wing splits the air, but the speed of air current above and below differs.
This causes the wing to rise in the air.

- How?
  Bernoulli could explain this, but can you?

In your groups, explain why the moving wing lifts the plane and why the house roof was being sucked upwards in the story ***When storm winds blow*** on page 133.

University of Cape Town

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

aerofoil	When the speed of a fluid increases, its pressure decreases
Bernoulli's idea	The lift-producing surface of a flying object
pressure	The force exerted on one square metre of surface

6.4 BREAKING FREE FROM THE SURFACE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain why the downward deflection of air streams produces lift.
2. Explain how lift is produced by the Bernoulli effect.
3. Demonstrate an understanding of how lift is produced in kites, helicopters and aeroplanes.
4. Explain the similarities and differences between bird flight and the flight of aircraft.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1 Using process skills to investigate Natural Science.
NS-SO2 Demonstrating an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Explain why the downward deflection of air streams will produce lift.
2. Explain how lift is produced by the Bernoulli effect.
3. Demonstrate an understanding of how lift is produced in kites, helicopters and fixed-winged aeroplanes.
4. Explain the similarities and differences between bird flight and the flight of heavier-than-air aeroplanes.

On a wing and a prayer



What is it like to be in real trouble in a small plane when landing seems impossible and the only way you can go is down? Kenny van der Spuy, a First World War pilot of a double-wing Sopwith Camel, recalls the moments before he crash-landed in a Russian forest in winter.

'Just when I thought I was safely home, my engine cut out completely. I was in a really tight spot! Vast forests stretching out for hundreds of miles all around me. I had no choice but to head downwards towards the forest. Unless I could find the small clearing I had spotted moments earlier, I would be lucky to get out of the aeroplane alive.

Coming in as low as I could over the trees, with a dead engine, I tried to remember every skill I had learnt at flying school - side-slipping, tail-wagging, wind-breaking... I only just cleared the tall trees at the far end of the clearing and the tiny Camel dropped in a flat landing. The wheels dug into the snow with a crunch, the nose followed and the aircraft whipped over onto its upper wing in a perfect half-loop. I had hoped it might. This would allow me to loosen my safety belt, drop out and get away into the forest.

But the severe crash impact had sheared the wing strut bolts off. The upper wing struts, now underneath the plane, collapsed and instead of hanging about twelve metres above the ground, I found myself flat on my back in snow with only the small curve of the pilot's cockpit around me. I was buried under the plane! To make matters worse, the petrol tank had burst and petrol was pouring over me. Fire is any pilot's greatest fear and I was terrified that the petrol fumes would reach the hot engine and explode in a fire ball.'

Adapted from: *Out of the blue. The role of luck in air warfare, 1917 - 1966* , L. Lucas

Read this story and discuss these questions in your groups:

- What is the function of the wings on an aeroplane?
- What is the function of the aeroplane's engine?
- What is the function of the tail?
- How do you think planes can fly upside down?

Archive: City of Cape Town

EXPLORING SCIENCE DEFLECTING AIR DOWNWARDS FOR LIFT

For this investigation, you will need an A4 piece of paper.

1. Hold the sheet of paper by its corners and gently blow against it.
   - Describe and explain what happened.



2. Let's make a kite using a plastic garbage bag.
   You will also need:
   two straight sticks (split bamboo) each about 90 cm long,
   a length of string and
   some sticky tape.

   - Use a short length of string to tie the two sticks together.
   - Cut the plastic bag to form a sail.
   - Use sticky tape to attach the sail to the frame corners.
   - Tie a loop of string from the point where the two sticks cross to the bottom end of the kite.
   - Tie a long string to the loop about a third of the way down.
     You will use this string to hold your kite when you fly it.

   Test your kite out.
   If the kite is unstable you may have to adjust the point where the string is tied to the loop or you may have to add a tail.



   To make a tail, tie a length of material to the bottom end of your kite.
   You will have to experiment to find the best length for the tail.

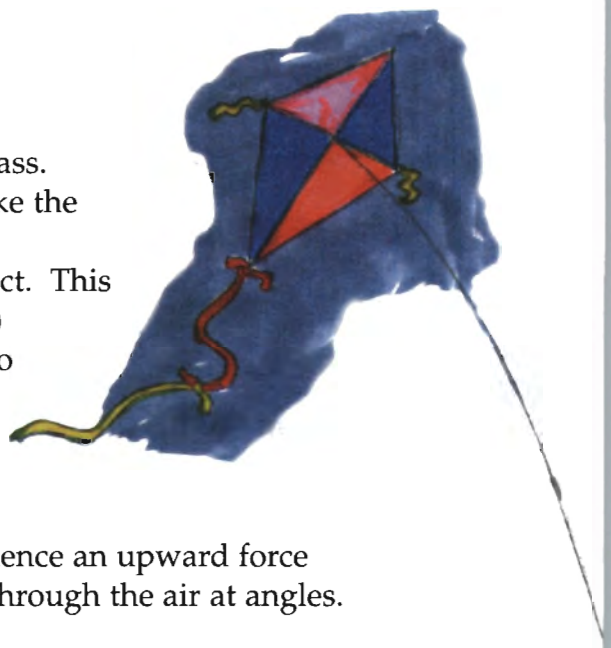
3. Fly your kite.
   Get someone else to hold the kite above head level, and then release the kite while you run into the wind, pulling the string.
   - What happens to the kite?

4. Hold the kite above head level again and pull on the string as the kite is released.
   - What happens to the kite?

5. Go back and look at your observation in point 1 and try to explain the behaviour of the kite in the cases of point 3 and point 4 above.

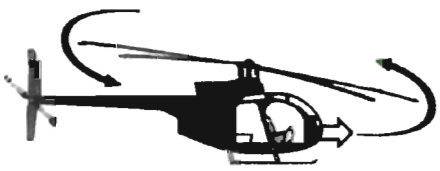
University of Cape Town

Kites and helicopters



When a ball is thrown against a window pane, the ball may bounce off the glass. The ball might also break the glass. When a moving object (like the ball) hits another object (like the window), they push against each other.
In the same way, moving air pushes against a moving object. This explains how kites fly. The kite deflects moving air (wind) downwards. The air moving downwards causes the kite to rise upwards.

The kite doesn't blow away because it is being held by the string. The combination of the upward push of the air and the tug on the kite's string causes the kite to experience an upward force and it soars into the air. You will notice that the kite cuts through the air at angles. This gives the kite more lift.



To go forward, the rotor blades of the helicopter are tilted forward. This deflects air down and back.

If you hold a thin piece piece of cardboard at an angle and swing it around you, you can feel the cardboard being forced upwards.
Air is deflected downwards by the moving sheet. This is also how the rotor blades of a helicopter produce lift.

The blades of a helicopter are set at an angle which deflects air downwards when the rotor spins. The blades are pushed upwards and lift the helicopter upwards.



To go backwards, the rotor blades are tilted backward. This deflects air down and forward.

The helicopter pilot can use the angle of the blades to fly forwards, backwards or to hover.
To fly forwards, the rotor blades are changed to deflect air downwards and backwards.
To fly backwards, the rotor blades are angled so that they deflect air downwards and forwards.
To hover, the rotor blades are adjusted so that the upward force experienced by the helicopter is exactly equal to its weight.



To hover, the rotor blades of the helicopter are set at the same pitch.

Like helicopters, humming birds also hover by moving their wings in a way that deflects air downwards. This helps them to stay hanging in the air while they drink nectar from flowers.

University of Cape Town

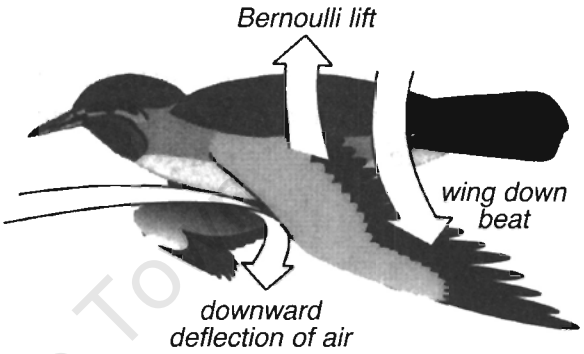
WHAT I HAVE LEARNT about air pushing up (lift)

In your groups, discuss which methods can be used to produce lift or push up the air.

Suggest which method is being used by
a hang glider pilot, a soaring eagle and an aeroplane pilot.

Producing lift

Lift is produced when air is deflected downwards or when air moves across an aerofoil. These two lift effects can be combined. Birds produce lift by flapping their wings in a way that uses both the lift produced by the Bernoulli effect and by deflecting air downwards and backwards.



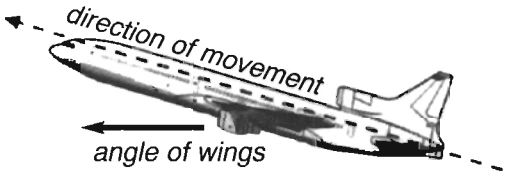
Bird flight

To produce lift:

- air must either move past an object or
- the object must move through the air.

Helicopter rotors move through air. Air moves past a kite.

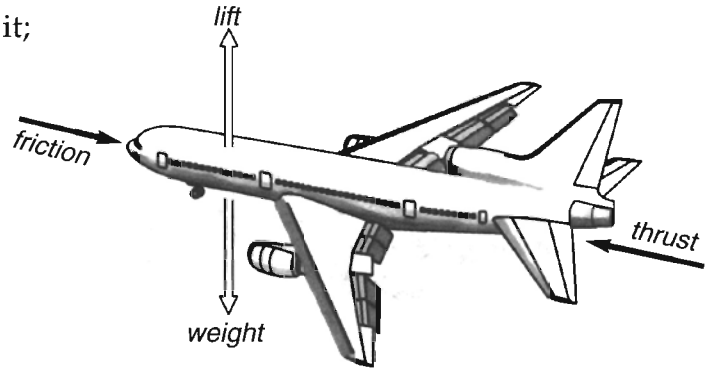
The engine of an aeroplane pulls the wings (which are aerofoil-shaped) through air. Wings produce lift by a combination of the Bernoulli effect and the deflection of air. The pilot holds the wings at an angle to the horizontal. The wings deflect air downwards and the plane experiences an upward force.



Aeroplane flight

To stay in the air, the plane has to move fast. It needs to overcome frictional drag. This drag is caused by:

1. the boundary layer between the wing and the air pulling other air layers with it;
2. the shape of the plane;
3. the formation of eddies.

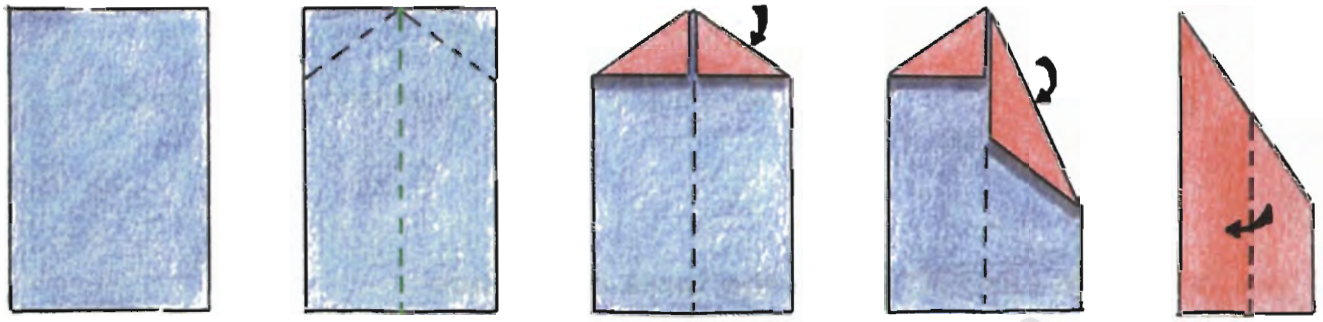


Aeroplanes are very heavy! The invention of powerful internal combustion engines in aeroplanes enables them to produce the thrust (forward force) to enable the plane to move fast enough through air for lift to operate.

University of Cape Town

EXPLORING SCIENCE STAYING ON COURSE

Pilots have to be able to control the position of an aeroplane in the air.
You need to make a paper plane to investigate this.
Follow the instructions in these sketches below.



1. Launch your plane a number of times to get used to flying it.



2. Bend the flaps down. Launch the plane.
   - What happened?

3. Bend the flaps up. Launch the plane.
   - What happened?

4. Bend one flap up and one down.
   - What happened?

5. Bend the rudder to the left. Launch the plane.
   - What happened?

6. Bend the rudder to the right. Launch the plane.
   - What happened?

7. Explain the function of the flaps and the rudder in steering planes.
   - Why do you think these surfaces work like this?

University of Cape Town

WHAT I HAVE LEARNT about flying

Answer the following questions in your groups:

1. What do both aeroplanes and helicopters share?
2. What do hang gliders and aeroplanes share?
3. What do kites and hang gliders have in common?
4. How do the aeroplane and helicopter differ?
5. Which movements can a helicopter carry out that a fixed-wing plane cannot do?

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

deflect	To remain suspended in one place
hover	To push out of its original path
lift	The upward acting force experienced by flying objects

WHAT I HAVE LEARNT about the tools of science

Scientists often have to solve problems which arise because we live on Earth. For example, how can we move rapidly through air and water or how can we transfer energy quickly. When we study nature, we can often find answers to our own problems. Scientists learnt a lot about flying by studying bird flight. They studied birds' bodies, the shape of their wings and how they are able to remain in the air.

University of Cape Town

LIVING IN WATER

7.1 THE FLOW OF LIFE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Identify the uses of water at different stages of the water cycle.
2. Demonstrate an appreciation of the safe use of water after flooding.
3. Design effective ways of purifying polluted water.

THE MAIN SPECIFIC OUTCOMES:

NS-SO1	Using process skills to investigate water usage.
MLMS-SO6	Using data to make informed judgements.
MLMS-SO3/T-SO1	Applying the technological process to a design problem.
NS-SO4	Scientific knowledge helping us to manage our natural resources.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Identify the uses of water in different stages of the water cycle.
2. Demonstrate an appreciation of the safe use of water after flooding.
3. Design effective ways of purifying polluted water.

The Days of the Big Rain



Bafana had not known a day like this before - the sky dark and filled with blue-black clouds although it was still morning. Just before lunch, the teacher came into the class and told them all to hurry home right away. The radio had forecast a huge storm with possible flooding.

Outside, children hurried home in all directions. Taxis and parents came to collect children. There was a sense of excitement in the air. Bafana shivered. It suddenly felt very cold and a fresh wind began to blow from the west.

The road to the bridge over the stream was full of laughing children, happy to be out of school so early. Suddenly there was a flash of blue-white lightning over the far mountains and a crash of thunder. Heavy cold raindrops began to fall around them, staining the dust red. More loud thunder, and then a wild, freezing wind began to shake the trees. The storm had started!

Bafana led a small group of scared children down the hill to the bridge. The stream had already grown in size. Brown foam-flecked water covered the road leading over the bridge. Bafana encouraged the smaller children to run across the trembling bridge. He carried the smallest one on his back. Anxious mothers met their soaked children on the road and hurried them home.

The storm lasted for three days. People only went outside to collect water. Bafana's mother boiled all the water before they drank it. She remembered that people had become ill with cholera after they drank the stream water during the last flood. Many had died. She didn't want her family to become ill.

On the morning that the clouds cleared and the sun came out, they saw what the storm had done. The bridge to the school had been swept away. Mealies and pumpkin plants had been flattened by hail stones and fierce winds. Drowned sheep were caught in fences. Homes had collapsed. And some people were to die because they drank polluted stream water.

Read this story and discuss these questions in your groups:

- Where does water come from?
- How does water get out of the stream and into our taps?
- What is cholera and how does it get into water?
- How can people protect themselves from infected water?

The flow of life - the Water Cycle



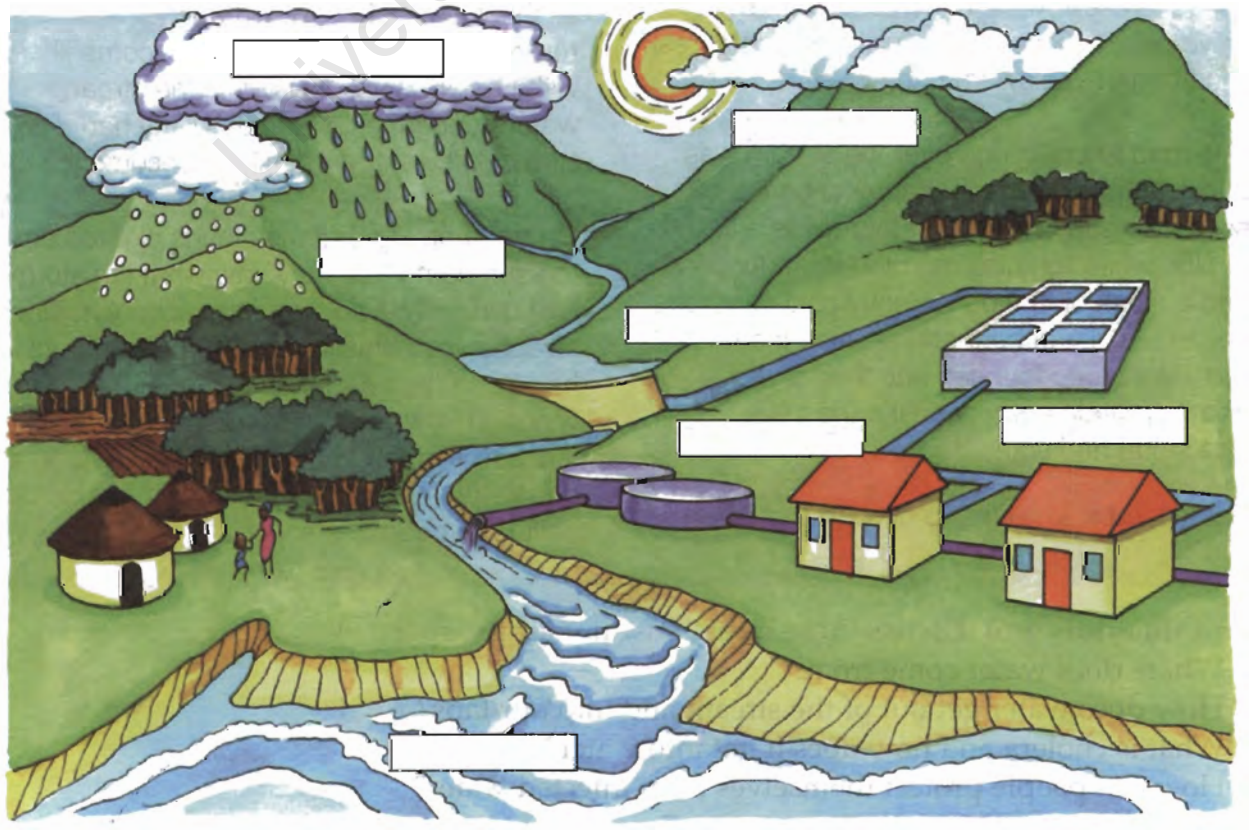
Water is essential for life. 65% of the human body is made up of water. We all need to drink up to six glasses of water a day (1,5 litres). Without water we could die within ten days!

The natural process of the **water cycle** ensures that we always have a renewed source of water. In this process, the sun evaporates water out of the oceans and dams. This water rises up into the atmosphere. The air in the atmosphere is very cold and causes this water vapour to condense and form clouds over the earth.
The temperature and air movements causes the clouds (water vapour) to condense to form water which falls to the earth as rain, hail or snow.

Rainwater is known as fresh water. On the ground, some of the rain soaks into the soil and is absorbed into the soil. This water collects in underground streams and becomes groundwater. The soil acts like a great filter, removing waste from the water.
Groundwater forms the **water table**. Groundwater is an important source of fresh water in dry regions like southern Africa. This water sometimes comes to the surface of the earth in the form of springs. In our country, many people use the groundwater which is reached by drilling a borehole and then pumping up the water through a water pump.

Other rain flows down slopes and forms streams. Streams join together to form rivers which flow through valleys. These rivers flow into dams or back into the sea.
Some of this water is evaporated by the sun and the water cycle begins all over again.

Make a copy of this illustration. Fill in the labels on your diagram.



University of Cape Town

Protection from polluted water

Fresh water is scarce in our country, so it is important that we look after this resource. Water in rivers and dams can become polluted by chemicals such as nitrates, phosphates or insecticides. It can also become polluted by animal or human wastes (faeces). Polluted water carries bacteria that cause diseases. When people use this water for drinking or washing, it can cause sicknesses like trachoma (eye disease) and gastro-enteritis (bad diarrhoea). It can even carry dangerous diseases like cholera, which can lead to death. Some disease-carrying pests can breed in stagnant water, like water snails which cause bilharzia and the mosquitoes which carry the malaria germ. Both of these diseases are life-threatening to humans.

Millions of people don't have safe drinking water and suffer from water-borne diseases. Each day, 60 000 people die world-wide because they drank 'killer' water. Today over 350 million people suffer from malaria, and 250 million from cholera, typhoid, diarrhoea or bilharzia.

Water has to be **purified** before we can drink it. Water treatment plants clean river water of pollutants and then pipe it to our homes. The waste water is returned to a sewage plant, cleaned and then returned to the river.

If people drink infected water without boiling it or putting chlorine (bleach) into it, they will become ill quickly. They will experience severe diarrhoea and vomiting. Their bodies will lose fluids too quickly and become dehydrated. If too much water is lost from the body, it can result in death, especially in young chidren.

There are ways to clean water in areas where the water is untreated or polluted. Remember that the bacteria that cause diseases cannot be seen with the naked eye. If you don't know if water is safe to drink, you can purify it in the following ways:



- **Boiling water** kills germs that may cause disease. Cool this water in a clean, covered container before drinking it.



- **Adding bleach** (chlorine) to water also kills harmful germs.
  Use one teaspoon of bleach to clean twenty litres of water.
  Allow the water to stand for an hour before using it.

A life-saving drink

People who get diarrhoea from drinking infected water need to sip this re-hydration mixture every five minutes until they recover:

- 1 litre of boiled, cooled water
- 8 flat teaspoons of sugar
- 1 flat teaspoon of salt.

This mixture enables the body to store water once again. It also replaces the salt lost through the diarrhoea and provides the body with sugar for energy.

University of Cape Town

EXPLORING SCIENCE HOW MUCH WATER DO WE USE?

Water is scarce in South Africa! The Department of Water Affairs and Forestry encourages us all to save water. One way to save water is to know how much water we use.

Water Audit - recording the use of water on an average day (at home or at school)

1. Record how much water you use to wash your hands. How many times a day?
2. How much water is there in a flush toilet tank?
   How many times do you flush the toilet per day?
3. How much water do you use to wash every day?
   A bath holds about 90 litres of water and a shower uses about 11 litres.
   A full bucket holds about ten litres of water.
4. How much water do you use to brush your teeth each day?
5. How much water do you drink each day?
   (Remember that all the liquids you drink are made up of some water!)

Record your water usage for one day in this **water audit table** below.
An example has been done to show you how.

University of Cape Town

Activity	Water used	Times per day	Calculate	Total litres per day
Wash hands	1/2 litre	3 times	3 x 1/2 litre	1 1/2 litre
Flush toilet				
Bath / wash				
Brush teeth				
Drink water				
			Total water used	

In your groups, answer these questions:

- How could you save more water?
- What other ways do we use water? How much?
  (Think of washing clothes, cooking and watering gardens.)
- Calculate how many litres of water your group used in one day.
- Calculate how many litres of water the whole class used in one day.

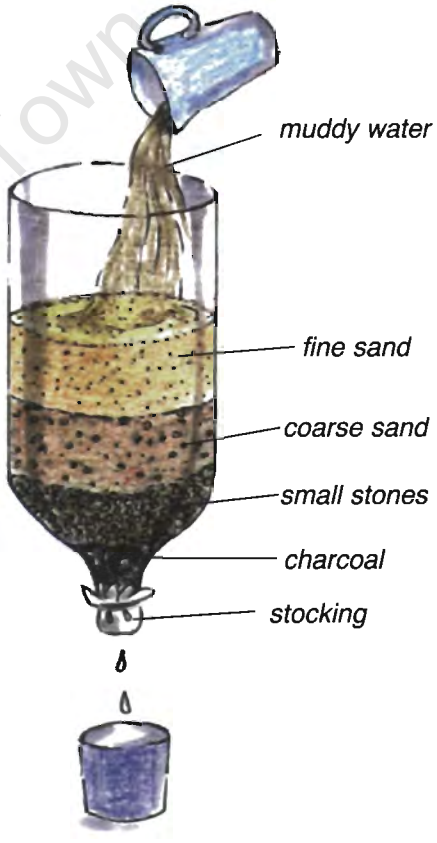
EXPLORING SCIENCE SAFE WATER - DESIGN A WATER PURIFIER



In this investigation, we will explore ways of purifying or cleaning water.

1. Boil a litre of water.
   Add three tea bags to the hot water.
   Then add two tablespoons of salt.
   (Imagine that this water is contaminated or polluted. Imagine that the salt is a disease-carrying bacteria and that the tea is a plant stain or dye.)
   - How would you clean this water to make it drinkable?

2. Discuss these ways of purifying this water: **Desalination, Filtering, Bleaching, Distilling or Boiling.**
   In your groups, research these ways to clean the water and test them out.
   Test the effectiveness of your experiments by tasting the water.
   - Is the water clean, free of salt and clear?



A sand filter for purifying water

Remember:

1. One teaspoon of bleach (like Jik) will purify 20 litres of water in one hour.
   - Why do you need to wait a while before tasting the water?

2. You can make a sand filter with boiled, washed river sand.

3. A sheet of glass and two small troughs can be used to make a solar desalinator (which separates the salt from the liquid).

4. With a pot, a hot plate and a wet cloth, you could turn the above apparatus into a distilling device.

Test your final water for colour, taste and smell.
- Which is the cheapest purifier?
- Which water purifier worked the fastest?
- Which of these purifying methods would be effective against bacteria like cholera? Why?



University of Cape Town

WHAT I HAVE LEARNT about the water cycle

What happened to all the water that...

1. flowed away in drainpipes after a heavy rain?
2. flooded the river and houses close to it?
3. sinks into the soil in the garden?
4. was flushed out of our toilets and our sinks?
5. was lost from the swimming pool?

Find your answers here:

- The water ran down slopes into streams and went into rivers and dams.
- It flowed away through the water table and reached the sea.
- It was absorbed by plant roots and was recycled through their leaves to the air.
- It settled over an area of non-porous rock and formed an underground lake.
- It was carried through underground sewers to treatment plants and released into rivers.
- It evaporated into the air and fell again later as rain.

Remember these new ideas

You have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

bilharzia	Water vapour that cools and collects as water droplets
bleaching	Condensed vapour which falls to the earth as water droplets, ice or snow crystals
chlorine	When a coloured compound loses its colour
cholera	The process of boiling water and then condensing it to obtain fresh water
condensation	A chemical which disinfects water when it releases oxygen
desalination	A parasite carried by water snails which infects humans
distillation	A bacteria that infects water and causes death to humans through severe water loss
evaporation	The process whereby water is evaporated to separate it from salt
filtration	Infection caused by mosquitoes carrying disease parasites
precipitation	The process of water (liquid) turning to water vapour (gas)
malaria	The separation of particle pollutants from a liquid

University of Cape Town

7.2 BIRDS IN THE WATER

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Gather scientific information about penguins and gulls from different sources.
2. Apply this information to decision-making regarding penguin conservation.
3. Communicate your conclusions in a report to your class.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Demonstrate an understanding of the scientific basis for the management of our natural resources.
NS-SO5 Using scientific knowledge to support decision making.
NS-SO6 Demonstrating an understanding for the possible distinction between the cultural and scientific views of penguin conservation.
LLC-SO4 Access, process and use information from a variety of resources.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Gather scientific information about penguins and gulls.
2. Apply the information to management policies for penguin conservation.
3. Communicate their conclusions as an organised report to the class.
4. Test their information against community opinions and come to their own decision.

Penguins in peril



On 20th of June 1994, the bulk carrier, *Apollo Sea*, sank during a fierce storm west of Robben Island. Thousands of litres of heavy fuel oil were spilt into the sea. A huge oil slick spread out along the West Coast polluting many beaches. The first signs of this oil pollution were the thousands of heavily oiled penguins struggling out of the sea at the breeding colony on Dassen Island two days later.

The penguins' feathers were waterlogged by fuel solvents that had removed the natural oils from their feathers. Their natural insulation was lost and they were exposed to the cold water. The penguins were cold, wet and very hungry. Many birds had swallowed fuel oil when they dived for food. Swimming and breathing were difficult. Their eyes were clogged with oil. They were dying when they should have been feeding their chicks and incubating their eggs.

A massive rescue operation was launched. Members of the public collected the oiled penguins and 7 000 penguins were flown to Cape Town. Their abandoned chicks on the island were rounded up and fed fish by hand. Four thousand adults birds survived, were ringed (flipper-banded) and released again near Cape Town. The birds that were oiled could not breed again that year. In the next season, they bred with unoiled birds but were less successful as fish-hunting pairs (as more of their chicks died) than those of unoiled established pairs that had not been separated in June 1994.

In your groups, try to answer these questions based on the story:

- Why did the oil slick move northwards?
- Why do penguins breed on off-shore islands like Dassen Island?
- Why were penguins breeding in winter on the island?
- What would be a sign that the conservation efforts were successful?
- How could we prevent a disaster like this from happening again?
- Why do we need to care for these penguins?

University of Cape Town

EXPLORING SCIENCE FINDING OUT ABOUT WATER BIRDS

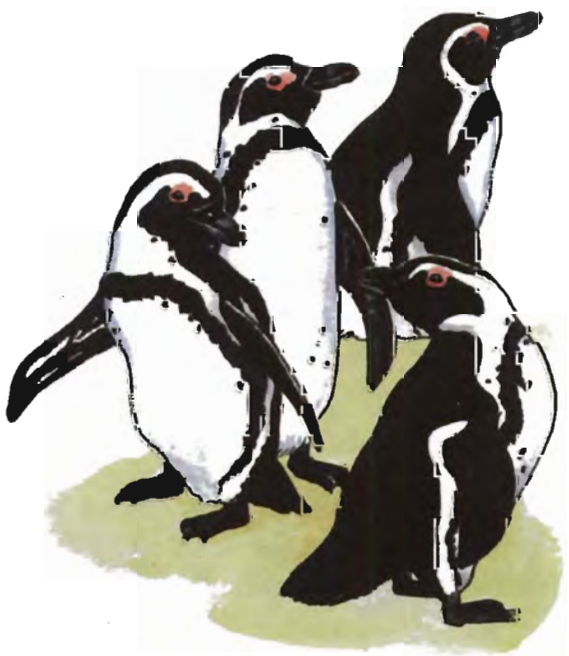
Study these pictures of kelp gulls and penguins. Use them to identify how these two bird species are adapted to living in water.



Read the list of statements about water birds below and try to match them to the two species. Read any books you can find and use your knowledge and skills to help you answer any questions you discover along the way.
(Be warned - there are some misleading statements here!)

This water bird:

- Catches food by swooping low over the water;
- Dives from rocks into the water to catch fish;
- Swims powerfully to great depths underwater after the fish;
- Nests in piles of stranded seaweed;
- Nests in tunnels and scrapes under rocks and bushes;
- Builds a floating nest of reeds;
- Nests mainly on offshore islands;
- Nests in large colonies around fishing harbours;
- Nests in colonies scattered anywhere around the coasts and even inland, near the coast;
- Prefers to eat squid, sardines and anchovies;
- Eats anything dead or that is small enough to kill;
- Eats only mussels which it opens by dropping them on stones;
- Is sometimes killed and eaten by seals;
- Has an egg which people used to collect to eat;
- Has small hairy feathers like fur;
- Has large quill feathers;
- Has webbed feet that are also used to absorb heat from hot rocks;
- Can swim at about seven kilometres per hour;
- Is often found scavenging on rubbish dumps;
- Eats kelp seaweed.



University of Cape Town

Prepare a short report for your class describing ways in which your chosen water bird is adapted for life in the water.
Include any additional information you have found out in your research.

Jackass penguins



A penguin on land looks like an awkward, clumsy bird which shuffles along with flipper-wings held forward for balance. But a penguin in water is a graceful swimmer. Under water, penguins beat their flipper-wings and seem to fly through the water. They can swim as fast as seals or dolphins.

When hunting, one or more penguins encircle a shoal of fish and dart in and out, taking the fish in their beaks. Ornithologists have found out that penguins can chase fish down to 500 metres in the water. They can hold their breaths for up to 15 minutes in very cold water! When a fish is caught, the penguin turns it in its beak and swallows it whole, head first. An adult penguin can eat as many as six pilchards for a single meal. When they are full of fish, they swim back to shore to feed regurgitated fish to their young or to incubate their eggs. When they get out of the sea, they jump upright out of the water and waddle-hop over the rocks to the site of their nest.

The parent penguins share the incubation of their eggs for 40 days before the fluffy brown chicks hatch out. Usually there is only enough food for one of these big chicks. The chicks cannot go into the water to feed until they have built up a fat layer and have grown their adult feathers.

In the early days, ships passing the Cape stopped for fresh food. The flightless birds on the islands were easy prey. Penguins were killed for food (though they tasted like fish), burnt as fuel in ship's boilers and boiled to extract lighting oil. Penguin eggs used to be very popular and were collected from the bird islands according to quotas. All egg collecting was officially stopped in 1967, but some illegal egg collecting still occurs.



During egg collections, penguins tried to defend their nests with their sharp beaks, but they were clubbed and kicked away. Their burrows were trampled on and their nests destroyed. Because penguins mate for life and use the same nests to lay their eggs in, this destructive harvesting disturbed their breeding patterns. Deserted egg clutches and chicks were often raided by gulls before the frightened parents could return. Today, jackass penguins are becoming an endangered species.

University of Cape Town

This map of Dassen Island shows a wall built by the guano collectors in the 1840's during the guano rush years. These walls were used to limit the area that penguins could nest in to keep them close to shore. This helped them to collect the phosphate-rich droppings easily. The guano was harvested and sold as fertiliser. But the wall also limited the breeding areas for the penguins. Where there were unprotected burrows, gulls attacked and stole the eggs, killing the penguin chicks.



It was once estimated that the penguins could eat up to 7 000 tons of fish a year. The local fishermen saw them as competition in the search for fish. Penguins could also easily cross over the top of a seine net and feed on the trapped fish. Due to over-fishing in the late 1960's, the pilchard and anchovy catches declined in the 1970's. The penguin population also dropped by 50%. Some fishermen still kill these scarce penguins and use them as bait for their crayfish traps in Namibia.

University of Cape Town

The bullies of the beach - kelp gulls

Kelp gulls are large black-backed gulls with strong yellow bills. Their beaks have a prominent red spot near the tip. They are scavengers and eat whatever they can find or kill. They are often seen on rubbish dumps near the coast, picking at food scraps. The sea, especially near harbours and beaches, is a place of abundant food. Gulls are increasing their range and have been seen up to ten kilometres inland and about 50 kilometres out to sea, along the length of our coasts.



Kelp gulls breed and rest together in colonies for security. When breeding, gulls need more space. The male gull paces off a territory and defends it noisily with beak and wing beatings. Males without territory are afraid of males with territory. This ensures that real fighting is rare. Ground is quickly occupied and the females know where the most aggressive males are found. The female gull has to be very careful when approaching the breeding area, for she may be pecked away easily.

When the female gull is accepted by the male, she helps to defend the territory. Once the eggs are laid, one of the parent gulls stays with the eggs and fledglings, defending them against other gulls who would eat them if they had a chance.

Gulls can land on water. They paddle along with their webbed toes. They keep their feathers well-oiled by using a preen gland near their tail and grooming their feathers at every opportunity. This keeps them waterproof and insulated by a layer of trapped air, even in the sea.



Gull beaks are powerful, hooked chisels for tearing and killing. They are strong fliers. Their main enemies are other gulls which try to steal their eggs and young. Because they feed their chicks by collecting food in their crops and regurgitating it for the young, they may be seen hustling other birds and bullying them into regurgitating their stored food for the chicks. This behaviour makes the gulls seem awful, but these are survival strategies.

In your groups, discuss this section about kelp gulls and try to explain how each behaviour pattern helps the gulls to survive. How do you think that gulls help us?

EXPLORING SCIENCE DO WE CARE ABOUT PENGUINS?

Read the story ***Penguins in peril*** to members of your family or friends. Write down their responses to penguins and whether or not they are worth conserving. In class, use this information you have collected to complete this data table.

Why we should care about penguins:	**Number of responses**
• Because penguins are beautiful, interesting	___ Interviewees
• Because penguins are a rare, threatened species	___ Interviewees
• Because penguins attract tourists with money	___ Interviewees
• Because penguins produce guano droppings	___ Interviewees
• Other reasons	___ Interviewees

Why penguins are unimportant:	**Number of responses**
• Because birds are only birds and not people	___ Interviewees
• Because penguins eat the fish people need	___ Interviewees
• Because penguins can't be eaten in any form	___ Interviewees
• Because money spent on penguins is a waste of money	___ Interviewees
• Other reasons	___ Interviewees

- What do *you* think should be done about our disappearing penguins?

University of Cape Town

WHAT I HAVE LEARNT about water birds

1. Water birds use a _____ gland to oil their feathers.
2. Some water birds have _____ feet to swim.
3. _____ can swim faster than fish.
4. _____ are cannibalistic feeders.
5. Kelp gulls have a red spot on their beak to _____ others.
6. Aggressive birds are better able to _____ their young.

Complete the sentences above by choosing your answers from these words:

- intimidate or stimulate
- penguins or gulls
- penguins or gulls
- preen or tail
- webbed or wide
- breed or feed

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

fledgeling	The phosphate-rich droppings of sea birds
guano	The chick before it can fly
regurgitate	To bring up (vomit) stored food to feed another bird

WHAT I HAVE LEARNT about the tools of science

A scientist who studies birds is an **ornithologist**. They classify birds and study the habits of birds. They assist in breeding domestic and wild birds.
Many South Africans are interested in birds. Some people like birds and their eggs as a source of food. Some people hunt them, some hunt with them (falconry), some farm with them (ostriches and fowls), some love them because they are beautiful and interesting or because they help to control insect and snail pests.

University of Cape Town

7.3 UNDER THE SURFACE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Use communication skills in art and language to express cultural values about hippos.
2. Explore alternative choices and suggest decisions about hippo management.
3. Research and find support information on fresh water life forms.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4	Scientific knowledge helping us to manage our natural resources.
NS-SO5	Using scientific knowledge to support decision making.
NS-SO6	Demonstrating an understanding for the possible distinction between a cultural perspective and a scientific conservation perspective of hippos.
LLC-SO2	Showing critical awareness of language usage in scientific context.
LLC-SO4	Access, process and use information from a variety of sources.
AC-SO1	To be involved in the application of knowledge to an art process and product.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Use communication skills in art and language to express cultural values about hippos.
2. Explore alternative choices and responsible decision-making about hippo management.
3. Identify some common life forms in healthy water.
4. Research and find support information on fresh water life forms.

Respecting the giant river horses



No one wants a hippopotamus living in their dam or river. Hippos or 'river horses' have a reputation for being dangerous and responsible for many deaths in Africa each year. Their huge jaws can snap a canoe in half and crush a man or a crocodile! At night, they move silently through the veld looking for their huge meals of plant grasses. As they graze, they may destroy unprotected farm crops and vegetable gardens near the river, so they are not popular.

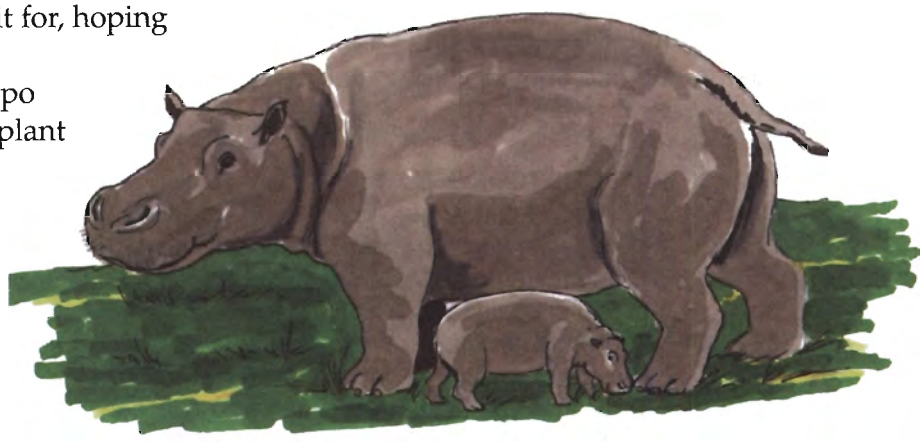
The hippo is one of Africa's largest and most interesting water mammals. It has been hunted so much for its meat, fat and leather that today it is a rare species. There are still about 2 000 of these giant animals in the Kruger National Park. To live with hippo, you have to respect them and understand their ways. They are the rulers of the river or lake where they are found. Hippos are useful animals. They trample open paths for other animals through dense reeds to the water's edge. Their interesting habits that make them great tourist attractions in our game parks.

Hippos love water! They need to wade in water to keep cool, moist and safe from lions. They mate in water, give birth to their calves in water, swim in it, rest in it, sleep submerged in it (rising to breathe in their sleep) and fight in it. Without water, they would die of sunstroke. Hippos have a very thin outer layer of skin and they dry out faster than other land animals. Regular mud baths help to protect their sensitive, hairless skins. The hippo's inner skin is up to six centimetres thick.

Hippos spend most of their days in shallow waters along lake shores, and on underwater sand banks in rivers. They live in groups. Fierce female hippos protect calves from bull hippos and hungry crocodiles. A hippo was once seen escaping from three starving lions by walking into deep water and lying down. A hippo can hold its breath underwater for up to six minutes, but a lion cannot do this!

University of Cape Town

At night, hippos leave the water and, with their calves, feed on grass, including food crops. This is the moment the lions wait for, hoping to find a calf wandering alone. On these feeding journeys, a hippo can eat almost 200 kilograms of plant food, returning to the river to digest the meal.



Dominant hippo bulls mark out their feeding territories with piles of dung which they scatter about to warn other males away. Fights are noisy clashes of gaping jaws, lasting until one or the other runs away or submits by lying down. In the crowded dry season, when there is less waterline space, some fights can be fatal.

What do people think about hippos?

This information on hippos can be interpreted in different ways.
In your groups, choose one of these three sections below.
When you have completed the exercise, share your conclusions with the rest of the class.

1. Hippo fear

Read the first paragraph of the story again. Imagine people who depend on water from a water hole which was taken over by a school of hungry, bad-tempered hippos in the dry season. This community's food supply is at risk but they are afraid to go to the water. Write a story called ***The hippos that stole a water hole*** in which you write about the problem and how it is finally solved.

2. Hippo respect

Read the second paragraph of the story again and discuss the following questions:

- How can people and hippos live together?
- What does it mean to have respect for hippos?
- What causes lack of respect for hippos?
- Why are hippos valuable animal resources in South Africa?
- What can be done to solve the problems of living peacefully with wild hippos?

3. Hippos and water

Read the last three paragraphs of the story again.
Use this scientific information to prepare an illustrated poster or brochure which shows hippos as amphibious animals that need both water and land by day and night.
Design the leaflet or poster for tourists who might visit a game reserve with hippos and want to see hippos during a bush trail or on a bush camp.

University of Cape Town

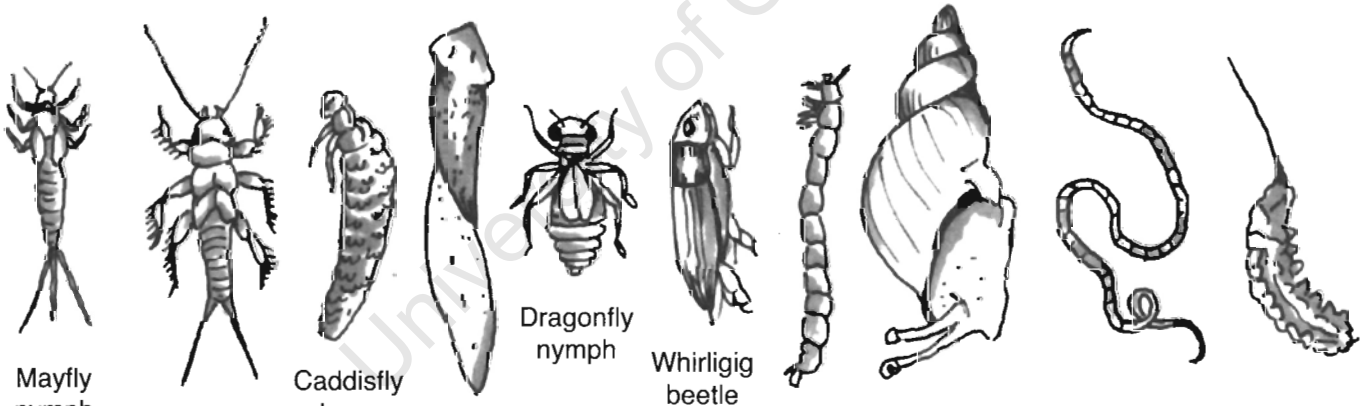
EXPLORING SCIENCE LIFE IN FRESH WATER

Visit a stream or ditch that has water plants and some shallow pools. You may find some interesting water animals!
Take a kitchen sieve, a white plastic bucket, two or three plastic jam jars or plastic margarine containers with you to collect some stream water. Also take some paper and a pencil with you, so that you can record what you see.



Bilharzia is a problem in South African waters, so it is important to avoid touching the water without wearing rubber boots and gloves, unless you are sure it is safe.

1. Look carefully at your site.
   Choose a variety of places to collect animals from - in mud, under stones, on water plants, on the surface of the water.
   Below are some small water animals you may find.
   - Put a tick next to each animal you found.





A common river frog

2. Place each animal in a white dish.
   Examine it with a hand lens.
3. Draw a sketch of the animal.
   Take note of its legs and any feathery parts that could be gills.
4. Return the animal to the water.
   Try to find out more about this animal back in the class.
5. If you can find a frog, study it and release it, unless it is a platanna. If it is a platanna, take it back to class.
   Carry it in a bucket filled with at least three litres of water.

University of Cape Town

EXPLORING SCIENCE A BOX-POND

To set up a box-pond, choose a sturdy cardboard apple or vegetable box.

1. Cut out four cardboard panels in each side. These will act as windows for your pond-box.

2. Line the box with tough, leak-proof, clear plastic.

3. Line the bottom of your box-pond with fine, washed gravel which you can sieve out of the bed of a stream or collect on a sea shore. (Make sure that the sea sand is well soaked in fresh water overnight to get the salt out.)



4. Place three fist-sized, washed stones in your box-pond. One stone should stick out of the water.

5. Place your box-pond in an are that is well-lit, but not in direct sunlight.

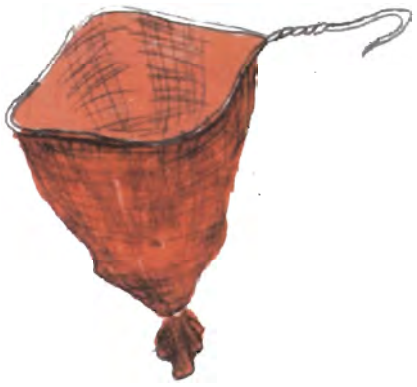
Stocking your box-pond

1. Collect six litres of representative water from a stream, lake or dam. Include surface water with plants and animals, bottom water and animals and a cup of bottom sediments (the mud at the bottom).

2. Collect one or two small rooted plants that can be planted in the box-pond.

3. Also collect some stones to stock your box-pond.

4. Try and get the water and the animals into the box-pond as soon as possible. Carry the animals in shallow buckets of water so they do not die from lack of oxygen or overheating.



You can make a small net out of a wire coat hanger and the foot of an old stocking to help you collect animals from the water

5. Pour the water slowly though a kitchen sieve onto a sheet of strong paper in the tank. Remove the paper after filling the tank.

6. The box-pond should be a third full of water. Add the animals and plants once the water is in.

University of Cape

WHAT I HAVE LEARNT about the secrets of living under water

In your investigations and information searches into fresh water life, you will have discovered some of the advantages of living in water. Check what you have learnt by linking the animals in the centre column with the **where** and **why** columns. The mayfly larva has been used as an example.

WHERE IT IS FOUND	WHAT IT IS	WHY IT IS THERE
Under stones ←	Mayfly larva →	Eats rotting plant matter
Skating over the surface	Dragonfly larva	Small insects on surface
Bottom in rotting leaves	Pond skater/Water strider	Eats water insects
In crevices under rocks	Whirligig	Dead animals and tadpoles
On the banks	Crab	Flying and swimming Insects
Swimming on surface	Frog	Insects fall onto the water
On water plants	Fish	Water plants are their food
On plants and animals	Snail	Blood sucking parasites
Swimming in water	Flat worm	Feed on plants and insects
Under stones	Leech	Dead animals in water

University of Cape Town

These animals live in the water because:

- they would dry out quickly in the air;
- their food is in or on the water;
- the water environment is a safe place to hide;
- they grow in the water for their vulnerable early stages;
- water protects them from extreme temperature changes.

In your groups, study this statement and try to decide which reasons apply to each of the animals listed above.

Remember these new ideas

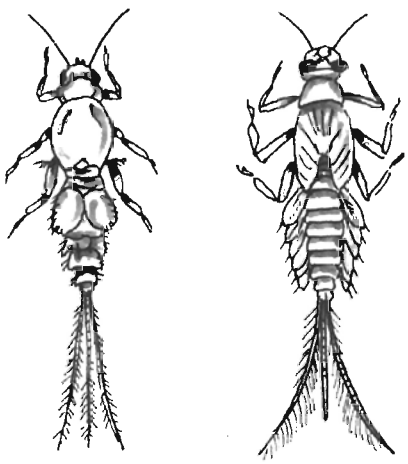
We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

amphibian	The faeces of animals
dung	An animal that lives in water and on land
territory	A feeding or mating area marked off and defended by a dominant male

WHAT I HAVE LEARNT about the tools of science

A scientist learns a lot by careful observation. The shapes of animals and plants tell us much about where and how they live.

For example, mayfly larvae have several different forms. Here are illustrations of two mayfly larvae which are found in our streams.
Can you tell in which part of the stream they might live? All mayflies have three antennae-like parts at the end of their abdomen for sensitive touch. A closer look at the gills on the abdomen tells us something more about them.



One mayfly larva lives under stones on the stream bed. Its gills are covered and protected from mud. The other lives in the stream vegetation and its gills are like paddles that help it to swim and move about quickly.

Can you tell which is which?

University of Cape Town

7.4 THE LIVING LAKE

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Describe what happens to nutrient levels in a lake.
2. Identify all the social influences affecting the problems at Wildevoel Vlei.
3. Identify some common life forms in healthy water.
4. Investigate platanna behaviour as a response to its environmert.
5. Estimate the approximate level of pollution in water using duckweed and insect indicators.

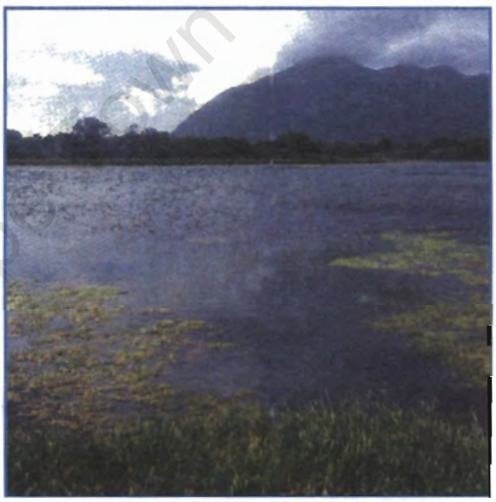
THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Understanding the scientific management and development of a resource.
NS-SO1 Using process skills to investigate Natural Science phenomena.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Describe what happens to nutrient levels in a lake.
2. Identify the human, social and economic dimensions in managing the problems of Wildevoel Vlei.
3. Investigate platanna behaviour as a response to its environment.
4. Estimate the approximate level of pollution in water using common duckweed and some insect larvae as indicators.

The lake that almost died



Do you know where dirty water goes when we flush a toilet or empty a sink or bath? What happens to all the chemicals and oil pollution from the roads and pavements that get flushed away by the rains into the stormwater drains? People living at Noordhoek in the Fish Hoek Valley recently found out the answer to both questions. Their lovely, peaceful bird sanctuary, Wildevoel Vlei, suddenly turned into a green poisonous soup. The edible mussels near the river mouth were tested and were found to be almost as poisonous as cobra venom! People were shocked. What had happened to their beautiful vlei?

In the past, Wildevoel Vlei used to dry up every summer season, but as more people moved into this beautiful area, there was more and more waste water to get rid of. The extra waste all ended up in the vlei. Development began to change the wetland. It was full of water all year round as the toilets of Noordhoek kept flushing and baths kept emptying. A small sewage works had been built there long before, but it could not handle all the extra sewage as housing expanded all through the valley and around the vlei.

There were also more roads and pavements to be drained during rainy days and all the storm water pipes led to Wildevoel Vlei. The sewage and drainage water was not pure rainwater. It had collected plant nutrients (nitrates and phosphates) along the way. These nutrients were costly to clean out of the water. What could be done? A new, bigger sewage works cost a lot of money. Who would pay for it? While people talked, the chemicals built up steadily in the vlei.

Then one day, the vlei could no longer contain any more plant fertilisers. A dangerous blue-green algae (plankton) began to turn the water green. The pondweed died and rotted, adding more nutrients to the water. The lake turned into a poisonous green soup, too dangerous to drink. Animals ate the pondweed and died. There were no more insects left. Frogs died, birds flew away. Wildevoel Vlei started to die!

Read through this story in your groups.

- What important questions were asked in the story?
- Using these questions, gather information about why Wildevoel Vlei was dying.

The poisonous algae in the vlei were flushed into the sea through the river and the nearby coastal mussels and crayfish became poisonous. The local authorities became very concerned. Mussel collectors might eat the mussels and die!

Wildevoel Vlei had become a public health hazard. Urgent meetings were held to discuss the problem. What would you have suggested if you had gone to the meeting in Noordhoek? Many ideas were put forward but no-one could agree on how to solve the problem and who was to take responsibility.



Mussels

Below are some of the suggestions put forward at the meeting:

Solution 1: Flush the algae into the sea by bulldozing a deep ditch through the beach dunes and drain the vlei.
(***But*** the rains may be late, the sea might close the ditch with sand at spring high tide, or more algae might reach the mussel beds.)

Solution 2: Build a bigger, better, more expensive sewage works.
(***But*** this will cost more and cause the local rates to go up.)

Solution 3: Sell your house and move to another area.
(***But:*** You may have to sell at a big loss because people would not want to live in the area.)

Solution 4: Build a long pipeline from the sewage works out to sea.
(***But:*** This will cost millions. It would also make other local beaches dirty as some sewage floats for a long time.)

Solution 5: Help to clean the vlei by putting tons of salt into the water to kill the algae.
(***But*** the salt would cost R60 000 and it would cost R300 000 to spread the salt. When the algae dies, the poisons will be released into the water again.)

Solution 6: Do nothing and wait and see what happens.
(***But*** people could die, all the animals will disappear and the wetland will become more polluted. If the vlei is left as it is, it may cost even more to fix everything up later.)

Every suggested solution has a risk factor or cost.
The only real solution is one that could solve the problem of pollution in the vlei permanently. In Noordhoek, a combination of suggestions was tried.

In your groups:

- Discuss which solutions the people of Noordhoek might have tried. Why?
- Choose one solution and explore its possible results.
  Present conclusions to the class.

University of Cape Town

Wetlands at risk

Rain and water from surrounding areas always flows downwards to a lake or a vlei. This water carries sediments and dissolved nutrients to the vlei where they settle as mud. A healthy lake contains the ingredients that growing plants need - sunlight, moisture and carbon dioxide from the atmosphere, water and nutrients. The nutrients washed into the water help the plant life to grow. The lake is full of animal life - insects, frogs, fish and birds. But sometimes too many chemicals or nutrient sediments are present in the water for the plants to use up. These nutrients then sink down to the bottom of the lake. Here they enable the poisonous blue-green algae to grow in the lake.

If the mouth of a river is blocked by sand and forms a lagoon, the mouth can be opened up by digging a channel. This would allow the over-fertilised water to escape. When it rains heavily, the rivers and streams also flush the dissolved nutrients out of the lake.

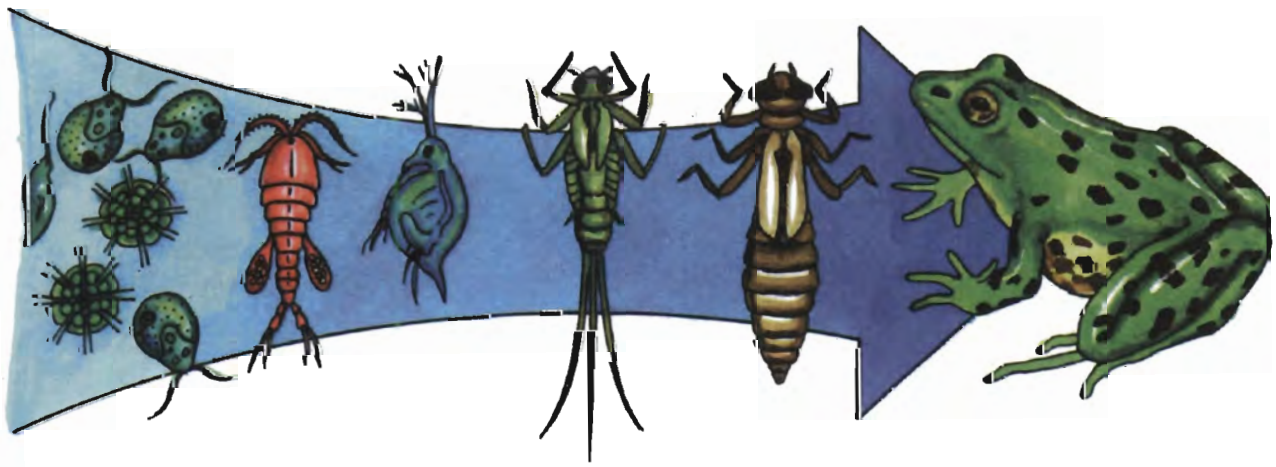
At Wildevoel Vlei, the fertilised water could not be flushed out of the vlei. The situation was made worse by the nitrate and phosphate wastes of the community getting into the water too fast for them to be removed by the pondweed and animals that fed on it. The lake became over-fertilised and the poisonous **blue-green algae** turned the vlei into a toxic soup. The water became dangerous to both humans and animals.



Types of blue-green algae seen under a microscope

Blue-green algae floats on the top of the water. It cuts off the light to the bottom-growing pondweed, causing it to die. In a healthy vlei, these algae would soon use up all the nutrients and die off as well, but if there is an unending supply of chemicals (nitrates and phosphates) flowing into the water, the algae thrives. This is man-made pollution!

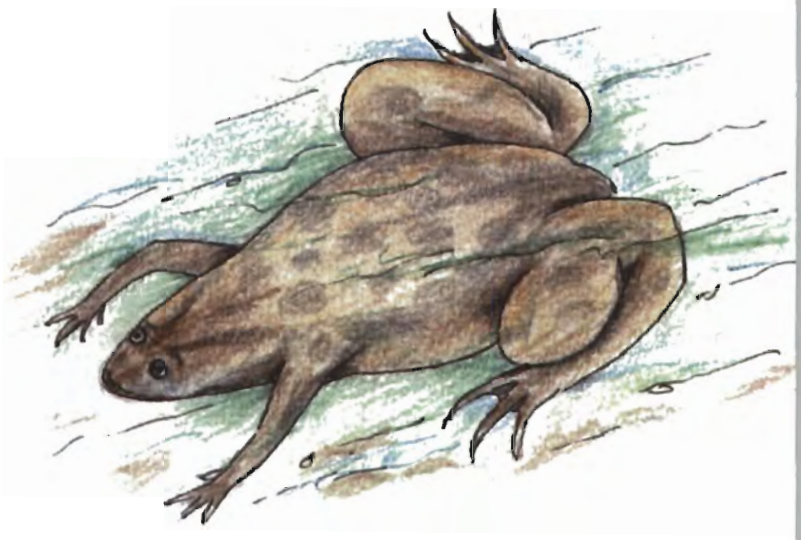
When this happens, the lake plants die, all the insect life dies, the frogs die, the fish lose their food supply and the birds leave the vlei. The whole wetland food chain breaks down and the lake dies.



A food chain in a healthy wetland

University of Cape Town

Platannas



Platannas are the most common toads in southern Africa. They live in dark, stagnant water often filled with rotting plants and mud. They have huge back legs and webbed back toes to kick their way backwards and forwards through the pond water. Their short front legs and sensitive fingers feel through the dark muddy water for food, which they quickly swallow whole. Platannas are the only toads to have claws on their fingers to help them scratch for food in the mud!

Platannas live in pools with little oxygen in them, so they need to rise to the surface of the water to breathe through their big lungs. They can smell food underwater and find it easily, whether it is living or dead. If the pond dries up in summer, they can sleep in a mud burrow below the surface by breathing through an air hole. One platanna lived in captivity for up to 15 years!

Platannas are the subject of much scientific research as their skins give off a slime which is rich in medical properties that kill bacteria, viruses and fungi. Platannas are the only South African animals to have ever travelled on the space shuttle in a research programme!

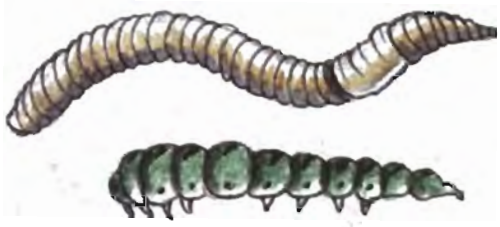
University of Cape Town

EXPLORING SCIENCE INVESTIGATING A PLATANNA

If you find a platanna in a stream or dam you can keep it for a while in your box-pond to study it.

- How often does the platanna rise to breathe air?

1. Feed your platanna on earthworms, caterpillars or some lean minced meat.
   - How does it eat?
   - Where does this platanna live?
   - Why is its body so flat and wedge-shaped and the back legs and feet so big?



Feed your platanna with earthworms and caterpillars

2. Put the platanna in a glass dish in an unlit classroom. Investigate the changes in its skin colour after a few minutes when sheets of light and then dark paper are placed underneath the dish.
   - Why do you think the platanna changes colour?

EXPLORING SCIENCE FURTHER BOX-POND STUDIES

1. Try to identify all the animals you put into your tank. Use library resources to help you identify as many animals as you can. You shouldbe able to find information on most of them easily.
   Try to see where each animal lives in the box-pond.



2. Add some well-decomposed (rotted) slimy leaves from the bottom of the vlei or stream to your box-pond.
   - What happens in the box-pond?
   - What changes?

3. Take note of the animals and plants.
   - Are any increasing?
   - What do they eat?

   Try adding things you think might fall into the pond or a stream (for example, a soggy dead insect, a snail, an earthworm, or some flower petals).
   - What happens?

University of Cape Town

EXPLORING SCIENCE WATER POLLUTION

To investigate the effects of detergent in fresh water, collect any floating plant, (like common duckweed) from a dam or vlei.

1. Place several plants in water in four 400 cm^3 plastic containers or jars on the window sill.

2. To each container of water, add different amounts of liquid washing-up soap:
   To the first add 5 cm^3 (1: 80); to the second 1 cm^3 (1: 400); to the third 0,1 cm^3 (01: 4 000) and to the fouth container 0,01cm^3 of detergent (1: 40 000).
   The phosphates in the detergent will add nutrients to the water.

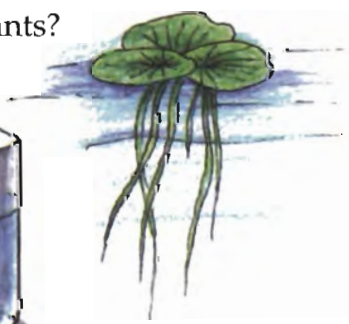
Study the duckweed carefully over a few days.
- What effect do the phosphates in the detergents have on the water plants?
- Record what you see. Why are your findings so important?


1:80


1:400


1:4 000


1:40 000


Duckweed

Remember these new ideas

We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

algae	Simple water plants that do not produce flowers (often microscopic)
nitrates	A plant nutrient containing phosphorus
phosphates	A plant nutrient containing nitrogen
sewage	Organic liquid wastes usually produced at home (food scraps, faeces, and dirty water)

WHAT I HAVE LEARNT about the tools of science

A **limnologist** is a fresh water biologist who studies the animals and plants that live in fresh water. They identify and measure the numbers of these species and use them as indicators of the health of the water. They are particularly concerned about water that is being disturbed by human activities and is dropping in quality as a result of river and stream abuse. This work is very important in a country, like South Africa, which has a serious shortage of good drinking water.

University of Cape Town

DIPPING INTO LIQUIDS

8.1 HOW MUCH DO WE DIP?

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain the concept of volume.
2. Calculate the volume of a rectangular solid.
3. Find the volume of a liquid.
4. Find the volume of a solid by displacement of a liquid.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Using process skills to investigate Natural Science.
NS-SO2 Demonstrate an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.
NS-SO2 Measuring with confidence and competence in a Natural Science context.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Define 'volume'.
2. Calculate the volume of a rectangular object.
3. Find the volume of a solid by the displacement of a liquid.
4. Demonstrate an understanding of a relationship between volume and displacement.

To catch a thief



The King was really in a bad mood today! He thinks that Goldix, the goldsmith, has stolen some of the royal gold. He does not trust Goldix at all, so I wonder why he let him make the golden crown? Everyone knows that it is easy to take gold and replace it with cheap zinc. The crown looks exactly the same and the thief is a richer man. But how can we prove whether Goldix is a thief or not? I hope we can, because his majesty has asked me to find out whether Goldix has used this trick in making the crown. With the bad mood he is in today, I think that I am going to have a hard time if I can't come up with the proof by tomorrow.

When I'm tired and worried, there is only one thing for me - a good bath! Oh dear, I've made it too full. Now there is water all over my bathroom floor. Too bad. A bit more won't matter! I wonder why water spills out like this when I get in? Hmm, I wonder *how much* water spills out when I get in? Would it be the same amount every time, if the bath was always full? Well, this might be my last bath for a long time if I don't solve the King's problem by tomorrow, so let me enjoy it.

Hold on! The King's crown will also push water aside just as my body did. If Goldix has not cheated when making the crown, then the amount of water pushed aside by it will be exactly equal to the same amount of pure gold. All I have to do to be certain is to find out how much pure gold it takes to fill a water hole the same size as the crown. If Goldix is an honest man, the new crown will weigh the same weight as the amount of pure gold and will push aside exactly the same amount of water as the original amount of gold did. If it doesn't - then the new crown is not made of pure gold!

Time to get out. Here I am standing on the cold, wet floor. But I'm much happier now! I know how to find the size of the hole the crown will make in water. Goldix, your days of cheating are over!

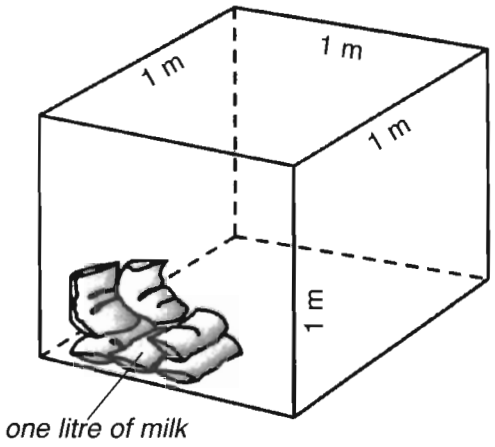
Read this story and then answer these questions in your groups:

- Why did the water spill from the full tub when the storyteller got in?
- How much water spills from the full tub?
- How can you find how much water has been pushed aside by an object put into or submerged in water?

How much milk is inside the bag?

Long ago, when people first started to farm and to sell food to each other, buyers needed to know how much food they were buying. Wheat, milk and wine could be poured into jars and sold. But how big was the jar?

When people started to trade with people from other areas, they all needed to know how much food was being sold for the agreed price.
What was a standard-sized jar? Today we know exactly how much milk we buy from the shop.
Milk is sold to us in standard-sized containers, bottles, cartons or plastic bags. The volume is always marked on the outside of the container.



A cubic metre

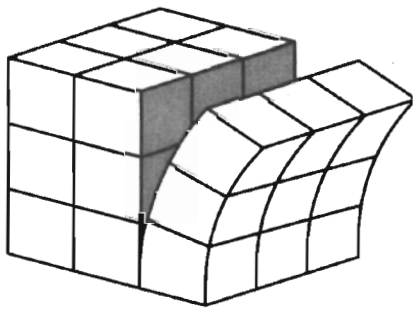
The amount of milk inside the container (1 litre or 2 litres) is called its **volume**.
The volume of milk is also a measure of the size of container it can fill.
The standard volume is the **cubic metre**. A cubic metre is a cubic box which has sides of one metre long.

A cubic metre would contain 1 000 plastic litre bags of milk. We all use much less milk each day. Imagine trying to carry home a container that could hold 1 000 litre bags of milk! This is a cubic metre. Milk is sold in a container which contains a thousand cubic centimetres. This is a decimetre of milk, but is more commonly called a **litre**.

EXPLORING SCIENCE FINDING VOLUMES

For this investigation, you will need some plasticine or modelling clay.

1. With the plasticine, make a cube with sides three centimetres long.
   Take your ruler and mark off centimetre intervals along each side of the cube.
   Use a knife to cut the large cube into the smaller cubes.
   Draw one of the small cubes. This is one cubic centimetre.
   - Count the number of cubes. How many are there?
   - What is the total volume of the original cube you made?



2. Use the plasticine again to make a rectangular block with sides of one, two and three centimetres each.
   Measure, mark and cut the block into cubes with one centimetre sides.
   - How many cubes are there this time?
   - What is the volume of the original block in cubic centimetres?
3. Imagine that you have a steel block that had sides three, four and five centimetres long.
   You would not be able to cut up the steel block.
   - How would you find out how many cubic centimetre blocks were inside your steel block?

University of Cape Town

Making a measuring box



You will need:
a small wooden block about one centimetre thick,
a strip of thin cardboard,
some gloss enamel paint, a paint brush
and some fast-drying glue.

You need to make this waterproofed box 24 hours before the investigation!

1. Shape the wood into a square with a side length of three centimetres.
2. Wrap a six centimetre wide cardboard strip around the wooden block. (The strip will need to be 12 centimetres long.)
3. Glue the cardboard strip to the sides of the wooden block to make a container.
4. Paint the inside and outside of the container with gloss enamel paint.

The next day:

To find the volume of a liquid, pour it into the container.
You now have inside the container a tiny liquid block with sides three centimetres by three centimetres with one side (the depth) still unknown.

5. To find the depth, take a thin straight reed or twig and push it into the liquid in one of the corners.
   Make sure that the reed is kept upright.
   Remove it, mark the liquid level and use your ruler to find the depth of the liquid.
   Find the volume by using the formula:

   Volume = 3 cm x 3 cm x liquid depth = _____ cubic centimetres.

6. Use your measuring box to find the volume of water contained in a teaspoon and a dessert spoon. In each case add four spoonfuls of water to the measuring box and find the volume added. To find the volume of one teaspoon or dessert spoon divide the total volume by four.

Keep your measuring box in a safe place. You are going to use it again!

WHAT I HAVE LEARNT about volume

In your groups, decide whether the following statements are true or false:

1. Volume is the measurement used to find the size of a field.
2. To find the volume of a rectangular object, multiply the values of three different sides.
3. The volume of a block which has sides three centimetres by four centimetres by eight centimetres is 96 cubic centimetres.
4. There 27 cubic centimetre blocks in a cubic block with side lengths of three centimetres.

University of Cape Town

Pushing water aside



What happens when we lower a solid object into water?

1. Half-fill a bucket with water. Mark the level of the water on the inside of the bucket.
2. Now lower a glazed brick into the bucket.

- Why does the water level rise?
  It seems as if we have added more water.
- Why is this?
  The brick has to push water particles aside to fit into the water so the brick has made a hole in the water.
- How much water (volume) has been pushed aside?
  Discuss this problem in your group.

EXPLORING SCIENCE HOW MUCH WATER IS PUSHED ASIDE?

University of Cape Town

You will need:
some plasticine or modelling clay,
two cups, a saucer and a teaspoon.



1. Half-fill one cup with modelling clay and shape the upper surface into a hollow.
2. Using the teaspoon, dig out a hole in the lowest part of the hollow.
3. Roll the modelling clay you dug out into a ball.
4. Place the other cup in the saucer.
   Fill this cup to the brim with water (without spilling any). Carefully lower the plasticine ball into the water.
   - What happened?
5. Lift the cup of water out of the saucer.
   Pour the overflow water in the saucer into the cup which contains the plasticine.
   Allow the water to run down into the hole in the plasticine.
   - Draw a sketch to show the level of water in the hole.
   - How does the volume of water which overflows compare to the volume of the hole made in the plasticine?
   - Is it the same or not?
   - How does the volume of the hole made in water by the ball compare to the volume of the hole made in the plasticine?



6. Repeat this investigation with the same plasticine ball rolled into a cylinder and then shaped into a block.
   - Is there any difference in the amount of water which runs out of the cup when the shape of the plasticine changes?
   - Does the volume of an object depend upon its shape?



EXPLORING SCIENCE FINDING VOLUMES BY DIPPING

When an object is placed in water it pushes water particles aside. We say that the object has **displaced** water. The volume of water displaced is exactly the same as the volume of the object - it doesn't matter what that object is - a ball, a cyclinder, a block, a body or a crown. This discovery allows us to find the volume of a solid by finding the volume of liquid it has displaced.

1. Use plasticine to make some small objects (of known volume) that can be dipped into your measuring box. Attach a cotton string to each object.

2. Always make sure that the container only holds enough water to cover the object you intend to dip.

3. Find the volume of the water in the container. Write it down.

4. Gently lower your plasticine object into the water and measure the new height of the water level using the reed. Find the volume of the water.



Make a table like this in your science book and complete it:

First volume of water in box	Known volume of dipped object	Second volume of water + dipped object in box	Volume of water displaced

5. Compare the known volume of the plasticine object with the volume displaced.



An eggsact fit

Imagine you are selling eggs in boxes of six. How would you build the smallest box that will hold the six eggs?

Discuss how to do this in your groups:

Discuss the design of the box.
Discuss building a box of this size.
Test your theory with real eggs.

University of Cape Town

WHAT I HAVE LEARNT about finding volumes

1. A recipe requires that you add 25 cubic centimetres of oil to flour.
   In your groups, decide how you will use your measuring box to measure 25 cubic centimetres of cooking oil.

2. In your groups, decide how you will find the volume of a marble.

Remember these new ideas

Select the meaning of these new words from the list below and then add them to your Natural Science dictionary.

volume	To remove or to take the place of or to move aside
displacement	The amount or size of a substance

WHAT I HAVE LEARNT about the tools of science

Scientists create new ideas or concepts to describe characteristics of material objects. Volume, for instance, is a characteristic of matter by which we compare the amount of that matter present. Scientists also describe how to measure or find the size of the said characteristic. To be able to compare objects, scientists carefully measure the size of the characteristic they are comparing. To be able to do this, they have to create instruments with which they can dependably measure the characteristic. The measuring box you made is an **instrument** with which volumes of some materials can be measured and compared.

University of Cape Town

8.2 FLOATING AND SINKING

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain why objects float or sink in water.
2. Predict whether objects will float or sink in water.

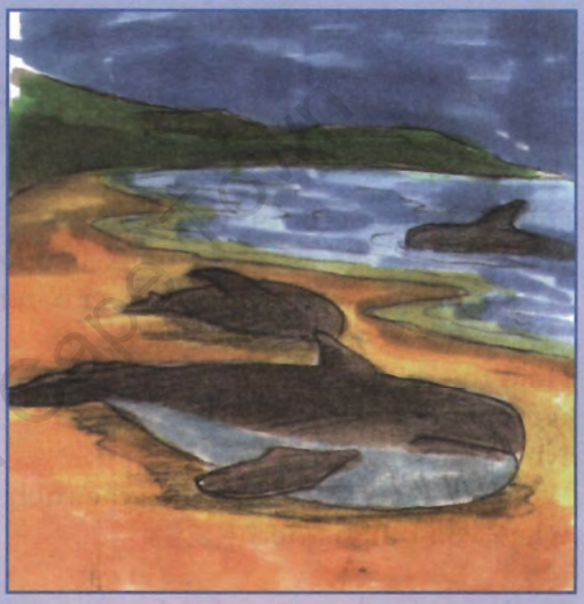
THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Using process skills to investigate Natural Science.
NS-SO2 Demonstrate an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Make and use a simple balance.
2. Explain why objects float or sink.
3. Predict how an object will behave when placed in water.

Whales on the beach



I was taking my dog for our usual early morning walk along the beach. We love this walk. I often discover stranded paper nautilus shells. Jasper chases seagulls and sometimes runs after a seal.

But this morning an awful scene met our eyes. To my dismay, I saw five pilot whales rolling about in the waves. They were clearly confused. They had lost their way and were in great danger of beaching. What could I do to stop this from happening?

Jasper started barking at them. I began to shout, but it was no use. The whales kept on coming nearer. What I had feared started to happen - the whales started to beach themselves in the shallow water.

The tide was going out and they would soon be in real trouble from the sun. I ran for help. People came running with buckets. We had to keep the whales wet and cool and cover them with water to prevent sunburn. But in spite of all our efforts, they started to gasp for air. Their breathing became slower and more laboured.

We realised that the whales' huge body weight was crushing their lungs. We had to get them into deeper water to make them lighter. Everyone ran home to get spades and soon we were frantically digging trenches around the stranded animals. John, a builder, got his water pump and hose and filled the trenches we had dug with water. The whales must have felt relieved. Their breathing became normal again. We had a long morning ahead of us until the incoming tide would allow them to float again, but we were determined save the beautiful creatures.

Use this story to answer these questions in your groups:

- Why do the whales feel heavy out of water on the beach, but not while swimming?
- Why does submerging them in water seem to make them lighter?

University of Cape Town

The mystery of the sinking cannon ball

Everything material on this planet has **mass** and is attracted to the Earth by the force of **gravity**. The force with which anything is attracted to the Earth is called its **weight**.
Things fall because they have weight.
Whales and other animals that live in water, are able to float in water.
They do not fall or sink to the bottom of the ocean. They seem to have no weight.

Discuss the following questions in your groups:

- What has happened to the weight of animals who live in water?
- Why do some things float in water, while others sink?
- Why do metal cannon balls sink in water, while iron ships float?
- Is there a difference between floating in water and floating in air?

EXPLORING SCIENCE LOSING WEIGHT IN WATER

For this investigation, you will need:
a strong rubber band, a brick, another fairly heavy object and a bucket of water.
(To make a long, strong rubber band, cut diagonally through an old bicycle tube.)

1. Hold the rubber band by its ends and stretch it for about five centimetres.
   Now pull harder.
   - What happens to the length of the rubber band when you pull harder?

2. Tie the rubber band to a brick.
   Pull on the rubber band to lift the brick.
   - How much did the rubber band stretch?

3. While holding the brick by the rubber band, lower the brick into a bucket of water until it is completely submerged.
   - What happens to the rubber band?
   - What has happened to the force with which the brick pulls on the rubber band?

4. Pull on the rubber band until the brick just touches the surface of the water. Keep pulling.
   - What happens to the length of the rubber band?
   - Why does this happen?

5. Now repeat the investigation with the other heavy object.



University of Cape Town

The liquid lift

When a brick is put into water, two things happen - it displaces water and it loses weight (the force which pulls it towards the Earth is reduced). We saw that the force of attraction between an object and the Earth depends on its mass.
The mass of the brick does not change when the brick is submerged, but it loses weight.

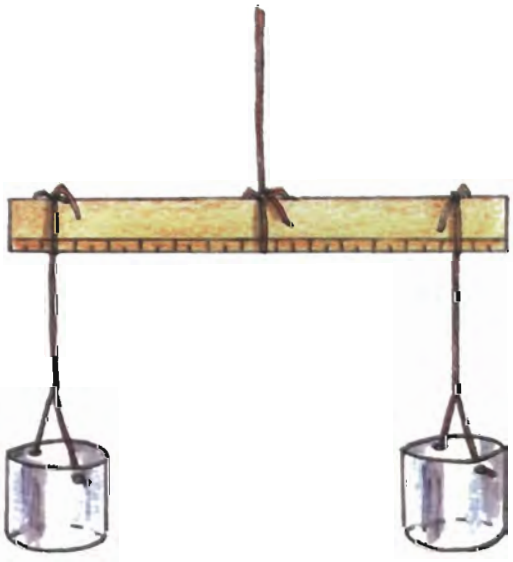
The reason for this apparent weight loss is that another force is pushing it upwards. This **upward acting force** is called **buoyancy**. All submerged objects experience a buoyant, lifting force. You experience this when you swim in water. The water pushes you upwards. The buoyancy of a floating object balances its weight exactly.

EXPLORING SCIENCE HOW MUCH BUOYANCY?

You are going to make a balance to enable you to compare the weight of different objects.
You will need:

a 30 centimetre ruler, two small plastic cool drink bottles, plasticine and a length of string.

1. Cut the top off the plastic bottles to make two same-sized containers.
   Make holes in the upper edge of each container.
   Tie a short length of string through the holes.
   Use equal lengths of string to attach the two containers to opposite ends of the ruler.
   Tie them securely so that they cannot slip.
   Tie a string to the middle of the ruler.
   Balance the stick and containers by moving the attachment of the string around.
   Mark the point of balance. Tie the string securely.
2. Make two differently-sized plasticine objects.
   Tie a cotton thread around each.
   Tie one of the objects to the plastic cup on the left of your balance.
   Hold the balance by the string and add dry sand to the plastic cup until the two sides are balanced.



3. Place a cup in a saucer and fill it to the brim with water.
   Carefully lower the plasticine object into the water until it is completely submerged by lowering the balance.
   - What happens? Explain the behaviour of the balance.
4. Now, while the object is still submerged, remove the cup from the saucer.
   Pour the displaced water into the cup to which the object is tied.
   - Which two weights are you now comparing?
   - What happens? Are both sides equally heavy again?
   - How does the weight lost by the object compare to the weight of water it displaced?
   - What determines the size of the buoyant force?

University of Cape Town

WHAT I HAVE LEARNT about buoyancy

In your groups, decide whether the following statements are true or false:

1. When an object is submerged in a liquid it gains weight.
2. The weight loss of a submerged object is called buoyancy.
3. The volume of liquid displaced by a submerged object is the same as the volume of the object.
4. The weight lost by a submerged object is the same as the weight of the liquid it displaces.

How much lighter is it?

When an object is submerged in a liquid it takes up space and displaces the liquid and it also becomes lighter. The weight lost by the object is equal to the weight of the liquid that filled the space it makes in the liquid. The weight lost by a submerged object is equal to the weight of the liquid it displaces.

In your groups discuss how the weight of an object:

- which **sinks** in water compares to the weight of water it displaces;
- which **floats** on water compares to the weight of water it displaces.

University of Cape Town

EXPLORING SCIENCE FLOATING AND SINKING

For this investigation, you will need:
your balance,
a cup and saucer
and some plasticine.

1. Make two fairly large plasticine objects.
   Make sure your balance is still balanced.

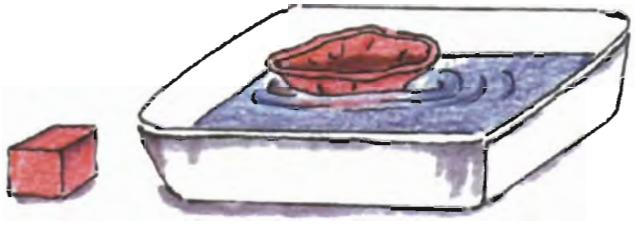
2. Fill the cup to the brim with water and place it in the saucer. Carefully lower one of the plasticine objects into the cup of water.
   Once the water has stopped running out of the cup, take the plasticine object out of the water.
   Dry it off and place it in one of the containers of the balance.
   Carefully pour the water from the saucer into the other container.



- What happens?
- Does the displaced water weigh more, or less, than the plasticine object?

3. Repeat the exercise for the other object.
- Is the weight of the liquid displaced by an object which sinks in it bigger, or smaller, than its weight?

4. Reshape both of the plasticine objects so that they will float on water.
   Repeat the investigation for one of the floating objects.
   - What happens to the balance when the weight of the object is compared with the weight of water it displaced?
   - Does the water weigh the same as the object?



5. Repeat the investigation for the other object.
   - Is the weight of the water displaced by an object which floats on it the same as its weight?

WHAT I HAVE LEARNT about floating and sinking

1. Things float when their weight is equal to the weight of the liquid they displace.
   Things sink when their weight is greater than the weight of the liquid they displace.

   In your groups, explain why:
   a brick sinks in water;
   a block of wood floats on water;
   a plasticine ball sinks in water;
   a plasticine boat floats on water.

2. A number of objects are to be placed in water to see whether they will float. What do you think will happen to them? If you know that 1 cm^3 of water weighs 1 gram, then use this information to complete this table:

Weight of object	Volume of object in cm^3	Volume of water displaced by object	Weight of water displaced by object	Weight lost by object
25 g	35			
60 g	45			
75 g	95			
125 g	135			

- Predict what happens to each of these objects in water and explain your prediction. Look at the first two columns of the table again.
- Do you think there might be a rule which can be used to predict how objects will behave when placed in water? What is it?

University of Cape Town

Remember these new ideas

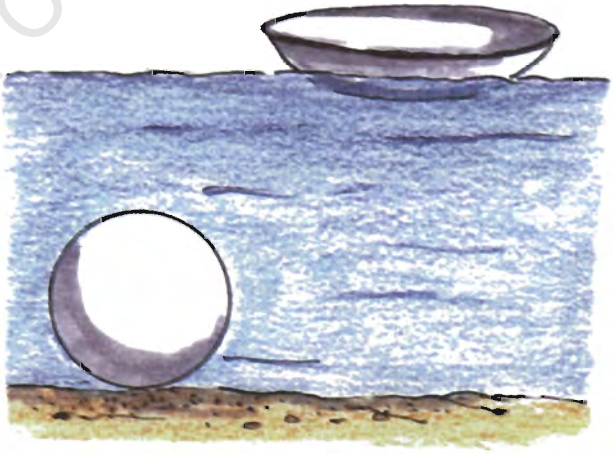
We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary.

buoyancy	The force of attraction which acts between all material objects
gravity	Weight loss experienced by a submerged object

WHAT I HAVE LEARNT about science and ship building

Scientists know that the volume of any material object is fixed, i.e. changing the **shape** of the object does not change the **volume** of the object. However, we can change **the size of the surface** of the object. If we take a cannon ball and change its shape into a flat plate, the volume and the weight of the plate will be exactly the same as the volume and the weight of the ball. However, the surface of the plate will be much larger than the surface of the ball. When submerged in water, the plate and the ball will both displace the same volume of water and experience the same weight loss.

Change the shape of the plate by turning the edges up. When this shaped plate is placed in water now, it sinks into the water and takes up a larger space than before. The upturned sides prevent water from covering the top of the plate. It sinks into the water until it displaces its own weight in water, so it floats.



This is what happens to an iron ship or a tin canoe. The vessel is shaped so that it can sink into water until it displaces its own weight of water. Any ship must be designed in such a way that it displaces its own weight of water.

When we load objects onto the boat, the combined weight increases and the boat sinks down further into the water and displaces an amount equal to the weight of the vessel and the load it is carrying. All ships are marked with a loading limit, called the plimsoll line, beyond which it is not safe to continue loading.

University of Cape Town

8.3 FLOATING IN WATER

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain why liquids float or sink in water.
2. Explain how water animals can maintain their position or depth.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Using process skills to investigate Natural Science.
NS-SO2 Demonstrate an understanding of Natural Science concepts and principles.
NS-SO3 Apply scientific knowledge and skills to problems in an innovative way.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Explain why liquids float on water.
2. Use density data to predict whether one immiscible liquid will float on another.
3. Explain how aquatic organisms maintain their depth below the surface.

A million tons of trouble



Supertankers are the biggest moving objects ever built by man! A very large crude oil carrier can carry almost a million tons of oil. A ship like this would equal the length of five soccer fields and be 3/4 of a length wide, with an underwater depth of 1/3 of a length. This ship is too large to enter any of the world's ports or even come close to most coastlines. Their vast oil-filled tanks are fairly safe as long as the engines keep running and can power the tanker away from rocky shores and other tankers. Collisions could rip them open and pour vast slicks of crude oil into the sea. This would bury hundreds of kilometres of coastline in thick toxic oil. Oil spills at sea are one of the world's major sources of pollution.

When fresh crude oil is spilt at sea it begins to change. The lightest fractions evaporate and pass into the atmosphere as gases. They also dissolve in the water. Rough water breaks the oil up into droplets that sink or rise up like aerosol mist into the air. What remains at the surface is a slick which floats on the water. This dark spongy froth of oil and water (like chocolate mousse) is carried up onto beaches by the wind and sea currents.

On beaches, oil causes devastation. It cuts off the light to plants and kills them. It clogs the gills, fur, feathers, eyes and mouths of animals. The detergents used to clean up the beaches are also dangerous and kill many times more animals than the oil slick itself. Sand blasting and mass sand removals are perhaps the most effective way to remove the chocolate mousse today, but these are very expensive processes.

Use this story to answer the following questions in your groups:

- What other ways does oil reach the surface of the sea? Read ***The story of oil*** on page 92.
- What other harmful effects of oil in the sea do you know about? Read ***Penguins in peril*** on page 151.

Oil slicks float **on** water, submarines and fish float **in** water, ships with holes in them sink **into** water. We have discovered that everything either:

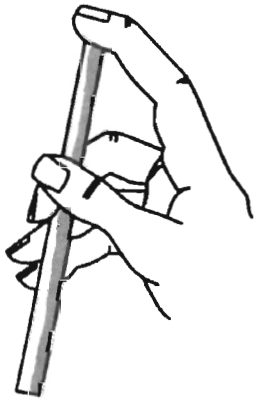
- floats in water when the water they displace weighs as much as they do;
- or sinks in water when the water they displace weighs less than they do.

- Why do you think oil floats on water?

University of Cape Town

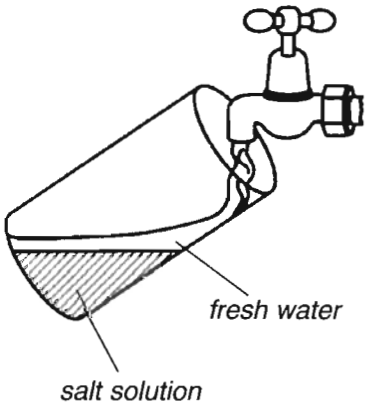
EXPLORING SCIENCE FLOATING AND SINKING LIQUIDS

For this investigation, you will need:
table salt, cooking oil,
your balance (see module 8.2),
a plastic colddrink bottle and a plastic straw.



1. Fill the colddrink bottle with cooking oil.
   Dip the straw into water.
   Place your index finger over the open end of the straw and remove the straw from the water.
   Place the straw into the oil in the bottle and remove your finger.
   - What happens?
   - What is the shape of the water drop?

2. Add water to a cup until it is about three quarters full.
   Add salt to the water and stir it with a teaspoon.
   Keep adding salt and stirring until no more salt can dissolve.
   Pour about half of this salty solution into a small container. (You will need this later on.)
   Add some food colouring to the salt solution remaining in the cup.
   Now carefully pour the coloured salt solution into the colddrink bottle.
   Wait until the solution stops swirling about.
   Carefully tilt the bottle to one side and slowly allow fresh water to run into the bottle until the layer of fresh water is about as deep as the layer of salt water.
   Now add cooking oil on top of the fresh water in the same way.
   Draw a sketch of what happened in the bottle.



3. You need your balance again.
   Make sure that it is balanced.
   Add five full teaspoons of fresh water to one of the balance containers.
   Add five teaspoons of salt water to the other.
   Compare the weights of the two containers.
   - Were the volumes the same?
   - Which liquid was heavier?

4. Pour the salt water out and dry the container.
   Add five full teaspoons of oil to the empty container.
   Compare the weight of the oil with that of fresh water.
   - Are the volumes of oil and water the same? Which liquid is heavier?

5. How do the weights of identical volumes of cooking oil, fresh water and salt water compare with each other? Write a rule which will help you to decide whether a liquid will float or sink in fresh water.

University of Cape Town

Thin enough to float?

A liquid which does not mix with water is said to be **immiscible**. An immiscible liquid floats on water when its weight is less than the weight of an identical volume of water. It sinks when its weight is more than that of an identical volume of water.

This rule is the same as the rule that we used to decide whether an object will float on water, except that we are now stressing that we must compare *similar* volumes.

One cubic centimetre of water weighs approximately 1 gram at room temperature.
If we wanted to decide whether a liquid or a solid will float on water we have to know what one cubic centimetre of it weighs.
We call the weight of one cubic centimetre of a substance its **density**.
The density of a substance tells us how much of the substance is present in one cubic centimetre of the substance.

Floating and sinking

- A cubic centimetre of water weighs about 1 gram - this is called the **density** of water.

If a liquid or solid weighing **less** that 1 gram per cm^3 is put in water, it will **float**.

If a liquid or solid weighing **more** that 1 gram per cm^3 is put in water, it will **sink**.

Clearly, substances with a density of less than 1 gram per cubic centimetre will **float** on water, while substances with a density of more than 1 gram per cubic centimetre will **sink** in water.

Here is the density in gram/per centimetre of some well-known substances:

Gold.....	19,0	Copper.....	8,9
Iron.....	7,8	Wood.....	0,9
Ice.....	0,92	Sea water.....	1,03
Cooking oil....	0,92	Motor oil.....	0,9

WHAT I HAVE LEARNT about liquids floating or sinking in water

In your groups, decide what will happen if the following substances were placed in a container of water.

Fresh water **sea water** **ice cube** **motor oil** **iron nail**

Draw sketches to show your final answer and describe why this would happen.

University of Cape Town

EXPLORING SCIENCE CONTROLLING FLOATING AND SINKING

For this investigation, you will need:

a large plastic colddrink bottle with a screw cap,
a medicine dropper or a small glass bottle which can fit into the colddrink bottle.



1. Fill the colddrink bottle with water.
   Suck water into the dropper so that it floats in water.
   Now place the dropper in the colddrink bottle.
   Screw on the top.
   Squeeze the colddrink bottle.
   - What happens to the dropper?

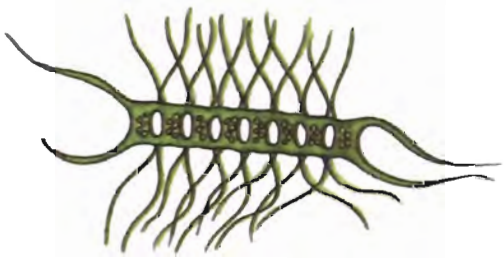
   Imagine that the dropper is a diver.
   - Can you try to make this diver hover in one place?
   - Why does the dropper sink, rise and hover?

Staying afloat in water

An object which does not displace its own body weight in water will sink.
If 1 cm^3 of the object weighs more than a gram, it sinks.
Water animals and plants concentrate chemicals in their bodies just like organisms on land. Eventually, one cubic centimetre of their body weighs more than one gram. This means that they will sink unless they can decrease the weight of one cubic centimetre of their body. How do they do this?

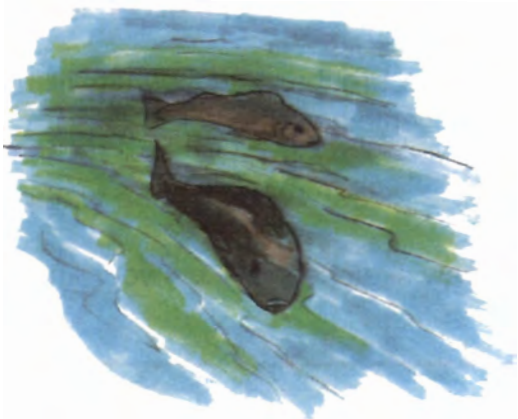
We have explored two possible mechanisms:

Firstly, we discovered that oil floats on water. If oil can be included in the body cells of organisms then they will not sink. Diatoms (single-celled green plants that live in the sea) produce and store an oil droplet in their cells. This helps them to float in the water.



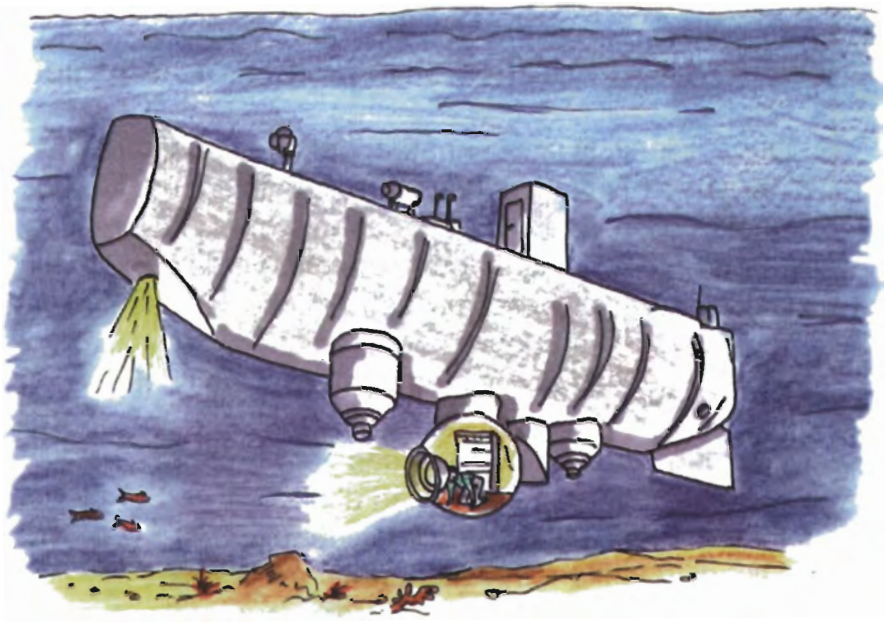
A diatom

Secondly, we discovered that by changing the volume of trapped air in the dropper, we could control its sinking. Many fish change their body volume by extracting nitrogen gas from their blood and keeping it in a body sac called a swim bladder. Nitrogen gas blows up the bladder and so the fish displaces a larger volume of water, and it stops sinking.



University of Cape Town

Marine engineers use the same ideas when they want to explore the underwater world. They have made machines called **submersibles** that can sink to great depths to explore the sea floor.



These machines have tanks filled with oil. To sink down, they are loaded with lead until they sink. To return up to the water's surface, the lead is released and the submersible floats up to the surface.

Submarine pilots control their underwater position by pumping air into tanks which are filled with water when they want to dive down into the water.

University of Cape Town

WHAT I HAVE LEARNT about floating

In your groups, discuss whether the following statements are true or false:

1. 1cm^3 of anything which floats in water weighs less than 1 gram.
2. A ship which weighs 10 000 tons sinks in water until it has displaced 10 000 tons of water.
3. When a whale floats at one level under water it has displaced a larger volume of water than when it floats to the surface.

Remember these new ideas

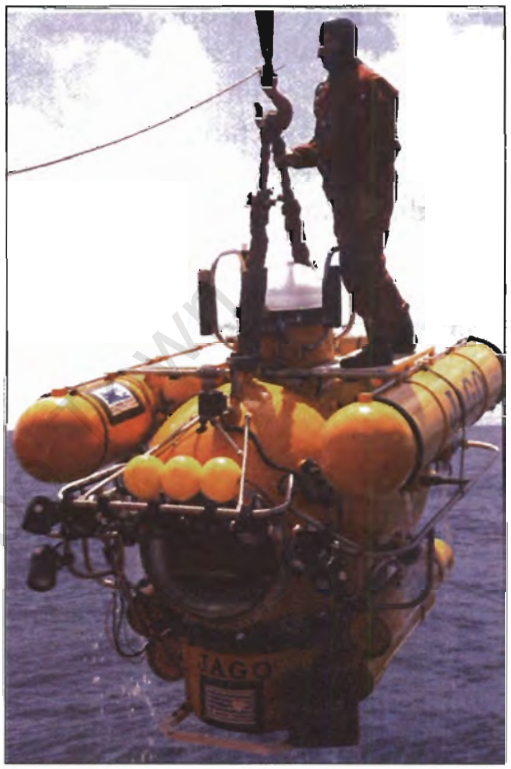
We have learnt these new words. Select their meaning from the list below and then add them to your Natural Science dictionary

density	Liquids which do not dissolve in each other
immiscible	The weight of one cubic centimetre of a substance
submersibles	Machines which are used to explore the sea bottom at great depths

WHAT I HAVE LEARNT about the tools of science

Marine scientists or oceanographers use submersibles to study the ocean floor at depths which divers cannot reach. In January 1960, Jacques Picard and Donald Walsh dived down to a depth of 11,5 kilometres. At this depth, the pressure is about 1 100 times that of the atmosphere. The cabin housing the scientists had steel walls which were between 7,5 and 12,5 centimetres thick.

In 1997, the Two Oceans Aquarium in Cape Town used a small two-man submersible called Jago to explore the ocean floor around the Cape Peninsula. Jago can dive down to 400 metres. Jago's depth is controlled by flooding tanks with water to make her sink. To make Jago hover or rise, water is pumped out of the tanks using compressed air. The scientists discovered some very interesting and unexpected animal populations on the sea floor.



Photograph by Michael Bruton

University of Ca

8.4 FLOATING IN AIR

WHEN YOU HAVE COMPLETED THIS ACTIVITY, you should be able to...

1. Explain how hot air and gas-filled balloons float in air.
2. Explain why balloons have to have large volumes.
3. Demonstrate an understanding of the similarities between floating in air and water.
4. Make a hot air balloon.

THE MAIN SPECIFIC OUTCOMES:

NS-SO4 Using process skills to investigate Natural Science.
NS-SO2 Demonstrate an understanding of Natural Science concepts and principles.

PERFORMANCE INDICATORS OF THESE OUTCOMES:

1. Explain why hot air and gas-filled balloons float in air.
2. Explain why balloons must have large volumes.
3. Demonstrate an understanding of the principles involved in floating and sinking in water and air.
4. Construct a hot air balloon.

The flying sheep

Today, the 19th September, 1783, will be remembered in history as the day of the big joke. The two Montgolfier brothers, paper-makers, are going to try to make a sheep fly in the air. I say that if sheep, and for that matter, men, were meant to fly, they would have wings. It is one thing noticing little pieces of paper rising in the hot air around a fire and maybe even trapping hot air in little paper bags as I believe they have been doing... but lifting a sheep up into the air? Never! Without a doubt, they are going to become laughing stocks.



Well, I must say, they have taken some trouble preparing for this event. I have never seen such a large paper bag in my life. And it's so beautifully decorated. I suppose they are trying to impress the King who is also here today. They are loading a cockerel, a duck and a sheep into the basket. Well, at least some have wings. They may need those wings to get this balloon off the ground. The poor sheep doesn't sound too happy to me.

They are making a fire under the mouth of the bag. I hope that the paper does not catch alight and burn the poor animals. Hey, look at this! The bag is swelling out and is becoming huge! The helpers seem to be straining to hold it down.

More straw on the fire, more hot air in the bag. Now they are letting it go. The balloon is slowly rising up into the air. The sheep is flying! It's amazing, unbelievable! And I'm seeing it myself! I feel a bit of a fool. The last laugh is on those of us who doubted. I must find out how this works. Maybe one day I might take off into the blue myself.

Read this story and answer these questions in your groups:

- How does air expand when it is heated?
- Why does hot air rise?
- Why do hot air balloons rise?
- Why are hot air balloons so big?
- How do hot air balloons stay afloat for long periods?
- How are hot air balloons controlled?

Supported by thin fluids

If you were a crab living on the ocean floor you could look up at fish and jelly-fish floating above you. Here, on the surface of the Earth, we can look up at balloons and other lighter-than-air objects floating above us.

Jelly-fish float in water and balloons float in air for the same reason: each is buoyed up by the weight of the fluid they have displaced. An object surrounded by air is buoyed up by a force equal to the weight of the air it displaces. You are about between 50 and 100 grams lighter than you should be, due to the buoyancy of the air around you.

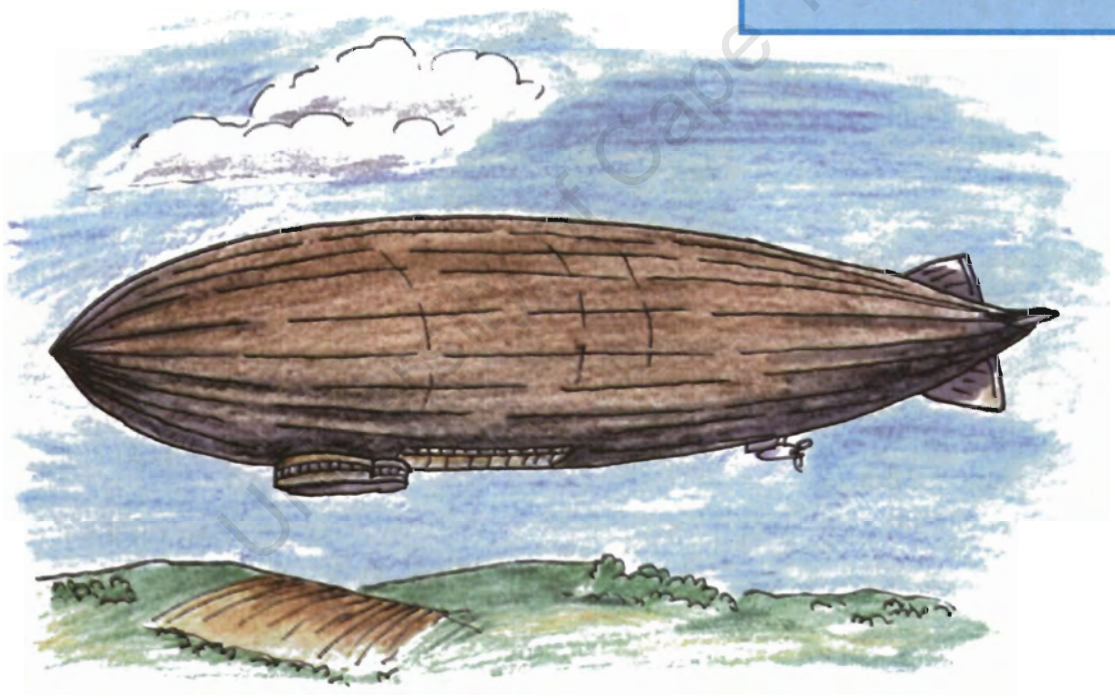
This fact is important in the design of balloons and other structures that float in air. So objects that float in air must have large volumes.

Weighing air and water

- A cubic metre of air at sea level on the Earth's surface has a weight of 1,2 kilograms.
- A cubic metre of water weighs 1 000 kilogram. Water is about 800 times thicker than air.

To float in water, an object needs a volume of 1 cubic litre per kilogram of weight.

For an object to become weightless and float in air, the volume must be one cubic metre for each 1,2 kilogram that it weighs.



After the First World War, Germany built a super balloon, a dirigible called a zeppelin. This zeppelin, *The Hindenburg*, carried people on trips from Germany to America. It was very luxurious and even had a piano in the lounge!

This dirigible was filled with hydrogen gas (which is lighter than air) and was 246 metres long. This is a very big flying object, even by today's standards.

Discuss in your groups:

Sometimes we blow up balloons that don't float up into the air.

- Can you think of a reason why they don't?

EXPLORING SCIENCE — HEAT AIR AND WATCH IT GROW

You will need:
a balloon, a plastic bottle and a container of boiling water.

1. Blow up the balloon.
   - What causes the balloon to expand or get bigger?

2. Pull the balloon over the neck of the bottle. Place the bottle in the container of hot water.
   - What happens to the temperature of the air in the bottle?
   - What happens to the balloon?

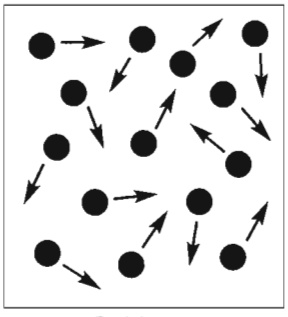
3. Take the bottle out of the water and turn it upside down.
   - What happens to the balloon?
   - Why does it inflate? Is it due to rising warm air?
   - Did you add any extra air to the bottle?
   - Where do you think the 'extra' air comes from?
   - Why does the balloon do this?
   - What happens to the amount of air that is left in the bottle?
   - What happens to the weight of the air that is left in the bottle?



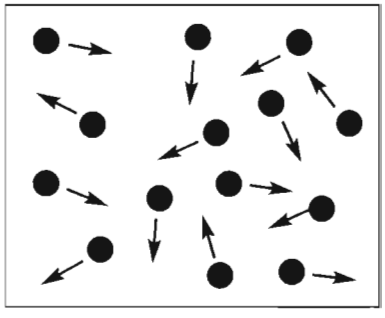
Place the balloon over the neck of a bottle placed in hot water

The mystery of growing air

When we warm the air in the bottle, the balloon inflates. It behaves as if we are adding extra air to the bottle and balloon.
However, the amount of air in the two does not change. The same number of air particles now occupy a larger space - the volume of the air in the bottle and balloon has increased. We say that the air has **expanded**. When air is warmed it expands. Its particles move more rapidly and the spaces between them increase, i.e. they become further apart and as a result occupy a larger space.



Cold air



When air is heated, it expands and takes up more space

A cubic metre of warm air contains less air particles than a cubic metre of cold air.
The weight of a cubic metre of warm air is less than 1,2 kilogram and as a result it rises or floats on the cold air.
Any gas which weighs less than 1,2 kilogram per cubic metre will float on air.
A cubic metre of hydrogen (the lightest gas) weighs 90 grams.
A cubic metre of helium weighs 180 grams. Both these gases float on air.

University of Cape Town

WHAT I HAVE LEARNT about floating in air

In your groups, decide whether the following statements are true or false:

1. A m^3 of cold air weighs less than a m^3 of warmer air.
2. Balloons and dirigibles have to displace very large volumes of air to float.
3. The weight of the volume of air displaced by a floating object is equal to the weight of the object.
4. Warm air floats on cold air.

EXPLORING SCIENCE MAKE YOUR OWN HOT AIR BALLOON

You will need:
three large plastic rubbish bags,
some sticky tape,
50 centimetres of thin wire,
aluminium foil and a source of heat.

1. Cut open the bottoms of two of the three plastic bags.

2. Use sticky tape to make one large bag tube of the three bags.

3. Use sticky tape to attach the mouth of the bottom end bag to the wire ring.

4. Make a long tube or chimney out of the aluminium foil.

5. Light a gas stove or burner and use the foil tube to guide hot air from the flame into the bag.
   Hold the bag in such a way that it will not catch alight.
   - What happens to the bag?

6. Release the bag when it is inflated with hot air.
   - What happens to the bag?



University of Cape Town

Up... up... and away...

Hot air balloons may be inflated with any gas as long as one cubic metre of the gas weighs less than one cubic metre of air. Balloons are anchored to the ground by sand bags in the basket.
To lift-off, the sand bags are taken out.
The balloon then rises and will do so for as long as the weight of air displaced is less than its weight.



As the balloon ascends (rises), the air around it becomes thinner. At some stage, the weight of the displaced air is equal to the weight of the balloon and it can rise no further. In hot air balloons, the air in the balloon cools down and has to be reheated regularly.



To return down to Earth, a flap is opened in the top of the balloon and some gas or hot air is released. The volume of the balloon decreases, the weight of air it displaces becomes less than its own weight and it floats down (descends). Most balloons have no way of controlling their sideways movement.

Dirigibles have engine-driven propellers which push or pull them along, but they cannot travel very fast because of their large size.

University of Cape Town

WHAT I HAVE LEARNT about balloons

In your groups, discuss the following:

1. The use of hot air balloons in game parks as a means of game watching. List the advantages and disadvantages of such a mode of transport.
2. The advantages of balloons over fixed-wing aeroplanes in rural areas.
3. The need for fuel in aeroplanes and in balloons.
4. The absence of living organisms adapted to floating permanently in air.

Remember these new ideas

Add this new word to your Natural Science dictionary.

dirigible ———— Large power-driven balloon

WHAT I HAVE LEARNT about the tools of science

Meteorologists and atmospheric scientists often gather information about the upper layers of the atmosphere. To do this they use weather balloons. The balloons are filled with helium and carry their instruments up to great heights in the atmosphere, so that they can collect information about the wind direction and wind speeds at higher levels. They use this information to forecast the weather more accurately.

Today, weather satellites are replacing this type of weather forecasting as whole weather frontal systems can be seen from high above the Earth.

University of Cape Town

ANSWERS

1.1 ARTHROPODS: THE SUCCESSFUL FLEA

Exploring Science - Reports of plague

- The plague must be endemic in Zambia.
- They live together in towns and there was a delay in correct diagnosis, increasing the number of plague carriers.
- The patients went home, carrying the disease with them.
- Clean up rubbish where the rats breed, kill the rats, kill the fleas, hospitalize the patients.
- Prevent carriers travelling out of the infected area until the plague stops.

1.2 LIVING WITH INSECTS

Exploring Science - Stopping a locust plague

- An insect.
- In semi-desert areas.
- Locust eggs need moisture to hatch.
- In many ways, e.g. crushing locusts with rollers, spraying them with poison, etc

Can you spot the queen bee?

- The queen bee is a large fertile bee that lives for many years.
- The worker bees are infertile bees that live for two months.
- They feed the bee grubs, clean the hive, collect nectar, make honey, guard the hive, carry water.
- Spring and summer are the peak seasons for nectar, thus honey, production.
- They live and work together in a community with different insects castes having specialized roles.
- The middle-sized bee with the round end to its abdomen.

1.3 THE WONDER OF SHELLS

Exploring Science - Designs for living in water

- For protection
- Molluscs have their gill chamber openings above their heads. They use a one-way water circulation system through the gills and out of its shell through the little holes along the edge.
- Seaweed fronds.
- No.

University of Cape Town

Exploring Science - Molluscs: survivors on the land

- They move about at night, after rains or in the cool wet season. They eat fleshy plants and drink water.
- They create a layer of mucous under their foot on which they move.
- From plants.
- By using lungs.
- Light colours reflect sunshine and help cool them. Camouflage markings hide them in light and shadow areas
- There is not enough calcium carbonate available and spines would be a handicap in moving through grass and leaves.

2.1 BRICKS THAT BUILD OUR WORLD

Exploring Science - Meeting solids

- No.
- The particles which make up the solid form heap together in shapes which do not change.
- We think that these forces are large forces.

Exploring Science - Liquids are different from solids

- Water spreads out.
- Water takes on the shape of the container it is poured into.

2.2 THE UMBRELLA OF LIFE

Mars, here we come!

- The brightness of Earth outshines the stars.
- The atmosphere and the oceans reflect or scatter blue light.
- Clouds.
- Impact craters from volcanoes and meteorites or asteroids.
- The Earth has many impact craters and volcanoes.

2.4 THE SHIFTING CRUST

What I have learnt about the Earth

1. 6 370 km.
2. Increases from 0^0C at the surface to 4 000^0C at the core.
3. Between 500^0C and 2 000^0C.
4. It is liquid.
5. It is solid.

3.1 WHERE FOOD COMES FROM

What I have learnt about food making

1. True.
2. False.
3. True.
4. True.
5. True.

University of Cape Town

3.3 YOU ARE WHAT YOU EAT

Exploring Science - Know what you are eating

- Plant fibres stimulate the bowels to get rid of waste.
- Yes, because it is 20 per cent protein.
- Organic compounds and inorganic trace elements needed by our bodies to keep them healthy and for normal growth.
- To prevent spoiling and to preserve the food and enhance taste and colour.

4.1 OUR STAR'S ENERGY

The Black Cloud

- Photosynthesis and warmth.
- They die from lack of sun.
- The Earth's atmosphere cooled, all water vapour condensed and precipitated.
- No sunshine warmth, everything wet, wind chill, unusually low temperatures in places not accustomed to frost.
- Less sunlight reaches us, days are shorter.

4.3 ENERGY IN OLD STONES

Exploring Science - Releasing trapped solar energy

- Heat energy, light, carbon dioxide, water vapour and ash.
- It is transferred when the chemicals in the wood react with oxygen in the air.
- It is much less.
- Weight of wood minus weight of ash.
- Substances are released into the atmosphere as carbon dioxide and water.
- Weight loss/original x 100.
- Weight of the ash/original weight x 100.

5.1 THE SECRETS OF FLIGHT

What have you learnt about bird flight

Missing words:

Backward
Upwards
Flapping
Upstroke
Downstroke
Air
Pressure
Thrust

University of Cape Town

5.2 MEALS ON WINGS

Exploring Science - Studying beak tools

Budgie - nutcracker
Gannet - spear
Flamingo - strainer
Vulture - meat hooks
Wood pecker - hammer drill
Shrike - meat hooks
Owl - meat hooks
Sugar bird - probe
Parrot - nutcracker
Duck - spoon

5.3 KNOWING WHERE YOU ARE

The flying fisherman

- To replace body reserves used up during mating, breeding and moulting.
- Oil pollution, exhaustion, predation on land and sea, insufficient fish food for fuel.
- They follow the coast.
- Feathers would be clogged up and won't be able to fly.

What I have learnt about bird migration and navigation

1. ...there is an abundance of insects in summer rainfall and temperatures never drop to freezing in summer.
2. ... the stars, the sun, sight of landscape features, the magnetic field of the Earth.
3. ... shortening length of the day and the availability of food.
4. ... absence of food, head winds, predation and oil pollution.

5.4 THE CHICKEN AND THE EGG

The egg farmer and the hen

- Water, shell grit, seeds, vegetables.
- Shells are thin and break easily.
- She leaves the nest to feed.
- The hen doesn't start to incubate the eggs until she has about ten eggs.
- True.
- Because they are not fertilized.

6.1 MOVING IN FLUIDS

Living in air and water

- Cohesive forces are forces of attraction which act between particles of the same kind while adhesive forces are forces of attraction which act between different particles.
- Larger in liquids than in gases.

University of Cape Town

- We have to ask ourselves how difficult is it to move the particles of a liquid apart compared to how difficult is it to move particles of gas apart. The boiling point of a substance is a measure of how difficult it is to move its particles apart. Substances which are liquids at room temperature have much higher boiling points than substances which are gases at room temperature.
- The force of attraction between particles and the distance between particles. In gases particles are far apart on the average while in liquids they are close together.
- Particles in solids are held in a fixed position in a crystal by large cohesive forces.

6.2 SLIPPING THROUGH

A flying start

- About two to three metres.
- The speed with which she leaves the water carries her to that height.
- No.
- No. Water is viscous and exerts a large frictional force on objects moving through it at speed.

6.4 BREAKING FREE FROM THE SURFACE

On a wing and a prayer

- To produce lift.
- To move the plane fast enough for the lift to overcome weight and once aloft, to overcome friction.
- To steer the plane.
- By angling the wings in such a way that air is deflected downward.

7.4 THE LIVING LAKE

Investigating a platanna

- Uses its front legs and sensitive toes.
- Lives in murky, stagnant water.
- For pushing through thick plant material and pushing under barriers.
- Camouflage in poorly-it conditions.

8.1 HOW MUCH DO WE DIP?

Exploring Science - Finding volumes

- 27 one centimetre cubes.
- 27 cm.
- 6 one centimetre cubes.
- 6 cm.

University of Cape Town

8.2 FLOATING AND SINKING

Exploring Science - Losing weight in water

- It becomes shorter.
- The force is smaller or reduced.
- It stretches or becomes longer.
- The brick is pulling harder on it or the weight of the brick increased.

8.3 FLOATING IN WATER

Exploring Science - Floating and sinking liquids

- A spherical drop of water forms and sinks through the oil.
- It is a sphere.
- Yes, we took five full teaspoons off each.
- The salt water.
- Yes, we took five full teaspoons of each.
- The fresh water.
- Salt water is heavier than fresh water which in turn is heavier than oil.

8.4 FLOATING IN AIR

Exploring Science - Heat air and watch it grow

- Air.
- Increases.
- Expands.
- It remains inflated.

University of Cape Town



NEW NATION SCIENCE GRADE 7

This is the first in a series of textbooks for the Senior Phase Natural Sciences Learning Area of the new curriculum. The authors have combined four themes that underpin this Learning Area, namely: The Planet Earth and Beyond; Life and Living; Energy and Change, and Matter and Materials. The Learner's Book has been written in a highly accessible style using stories and activities which will encourage active participation by the learners as they work through the text.

Key Features:

- Beautifully designed in full colour
- Each unit is introduced by learning outcomes
- Each unit looks at issues in Natural Science in the form of an interesting story
- Each unit has activities for the learners which require them to investigate, analyse, apply and demonstrate an understanding of the topics covered
- A variety of individual, pair and group activities is included

Teacher's Book

A comprehensive guide for the teacher on how to make optimum use of the material provided in the Learner's Book. The Teacher's Book also provides useful suggestions on all aspects of outcomes-based education within the Natural Sciences Learning Area.

University of Cape Town

ISBN 1-874-958-70X

9 781874 958703

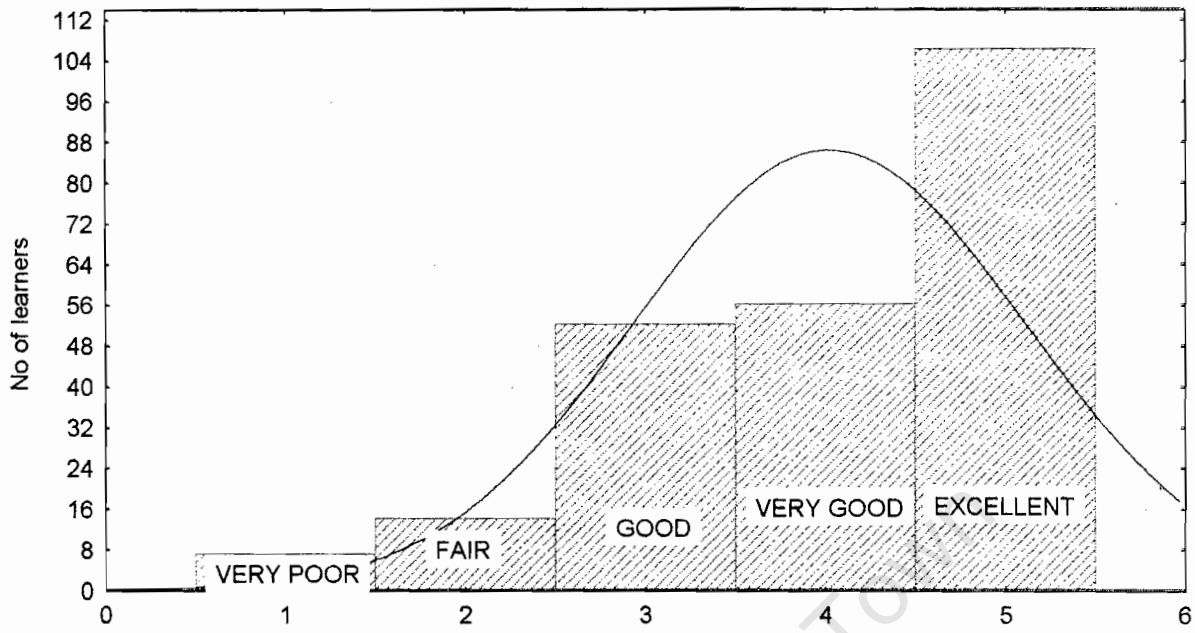
Hodder & Stoughton

APPENDIX 6

EXAMPLES OF RATINGS

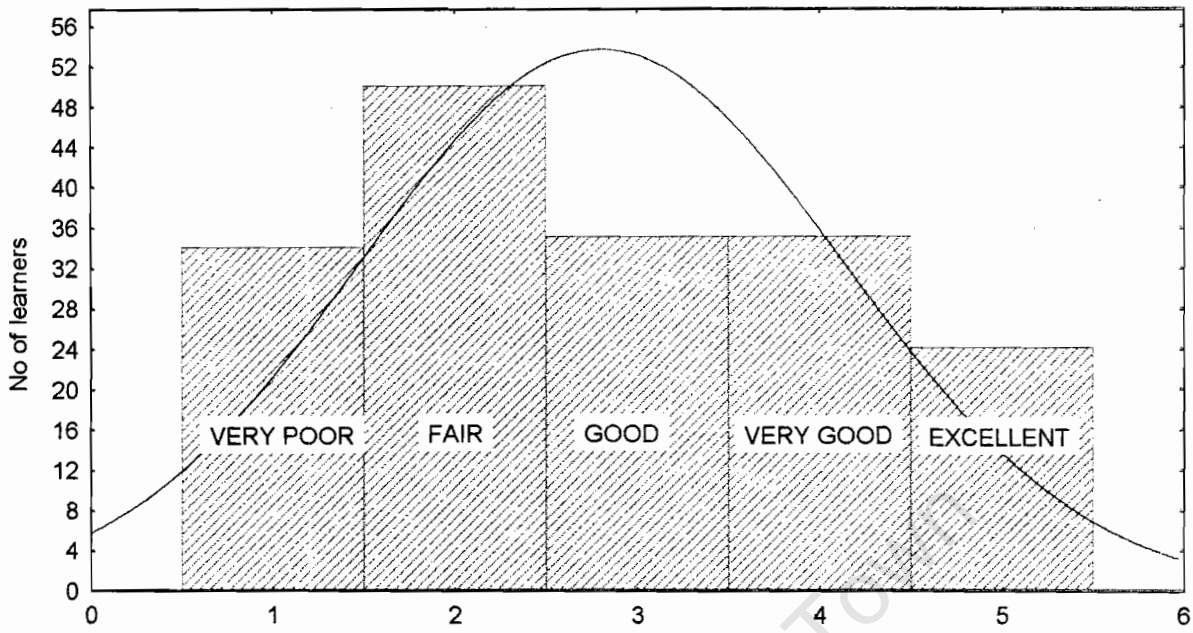
University of Cape Town

Frequency distribution of 235 advantaged learners' ratings
for the illustration of the fly (textbook page 5)



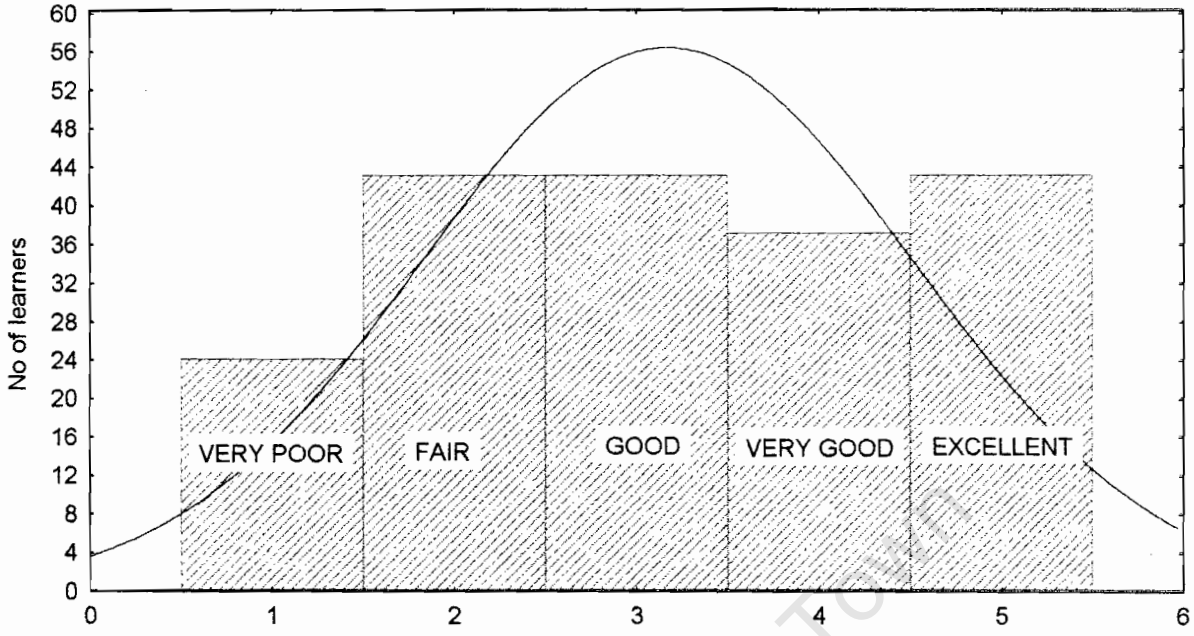
University of Cape Town

Frequency distribution of 178 disadvantaged learners' ratings
for the illustration perlemoen (textbook page 14)



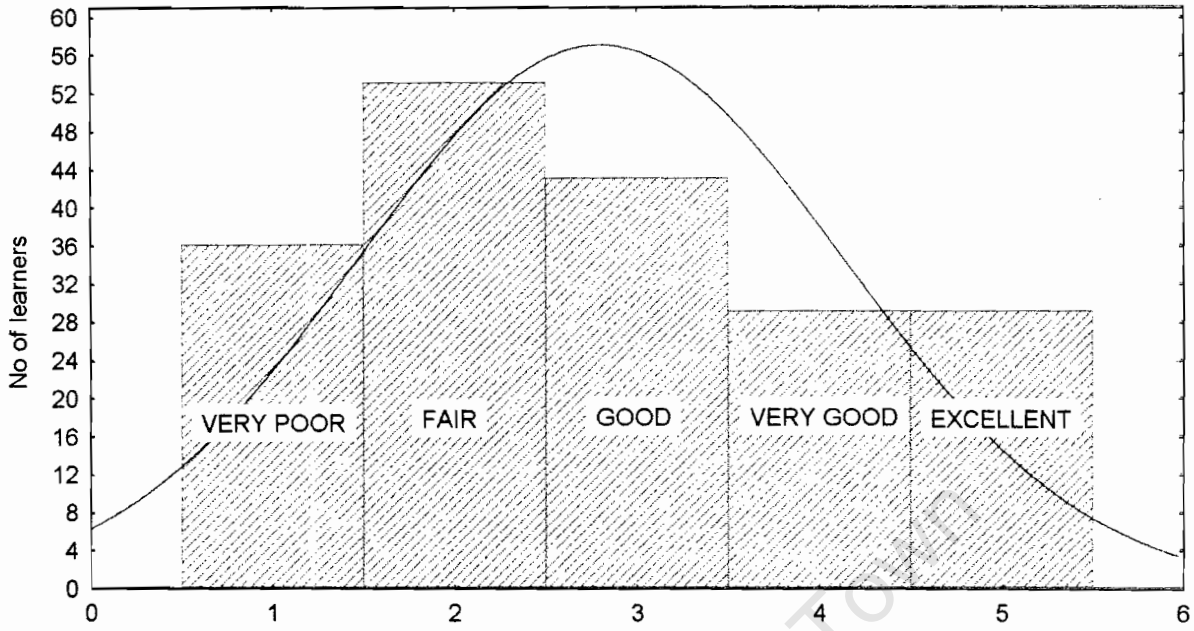
University of Cape Town

Frequency distribution of 190 disadvantaged learners' ratings
for the illustration foundation of earth (textbook page 44)



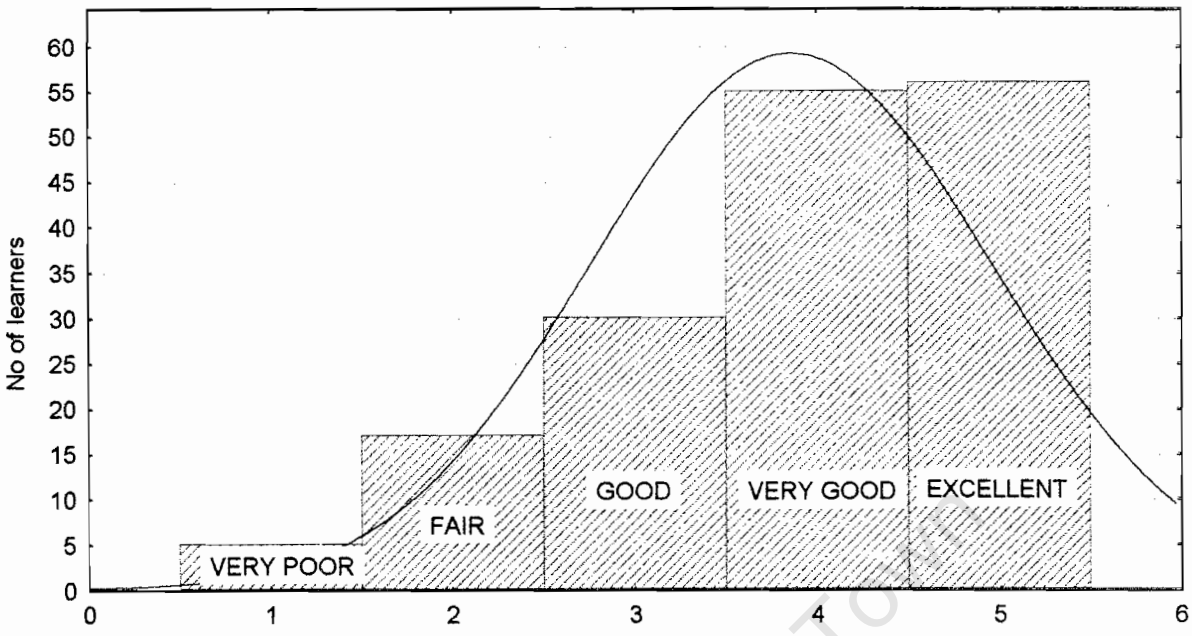
University of Cape Town

Frequency distribution of 190 disadvantaged learners' ratings
for the illustration squid hunting (textbook page 37)



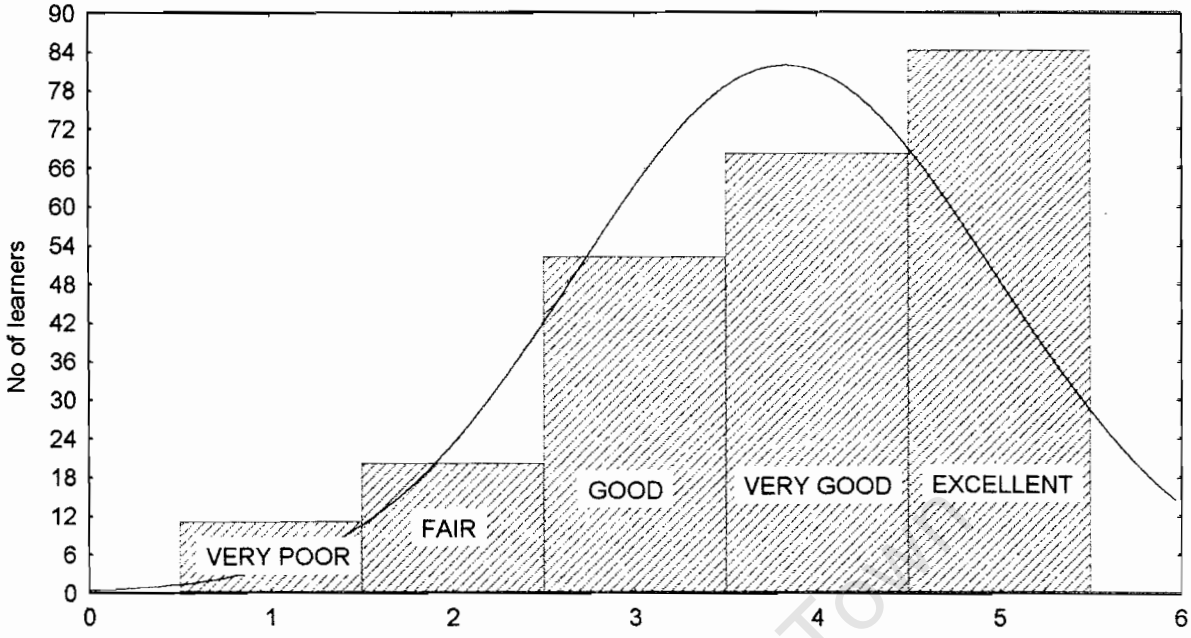
University of Cape Town

Frequency distribution of 166 advantaged learners' ratings
for the illustration ostrich (textbook page 116)



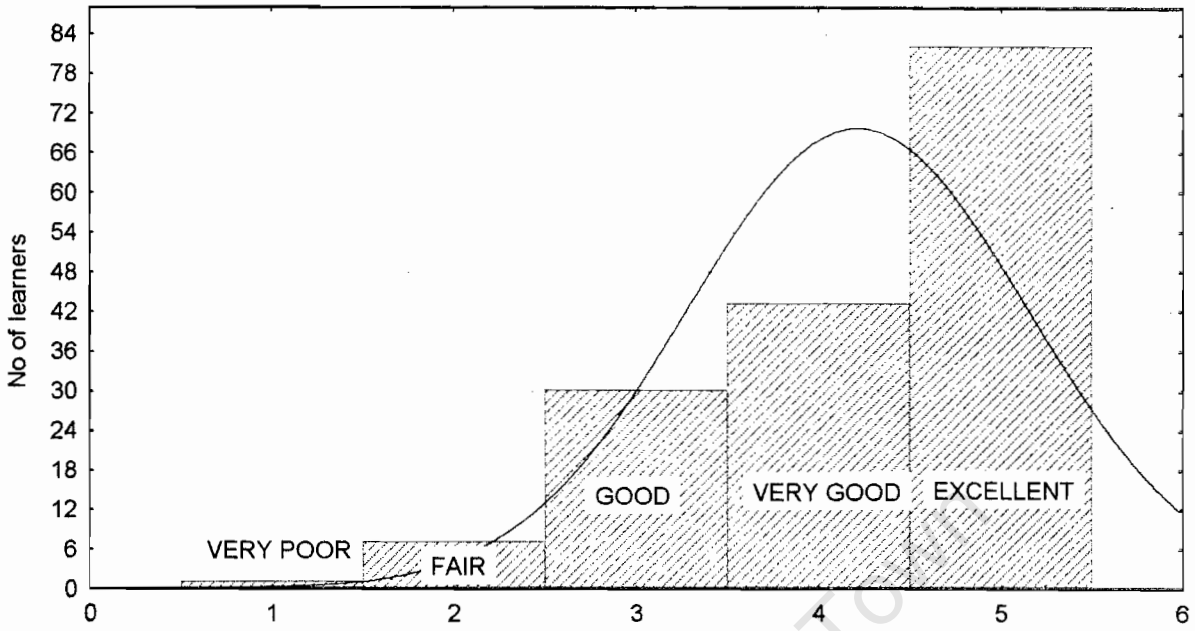
University of Cape Town

Frequency distribution of 235 advantaged learners' ratings
for the illustration perlemoen (textbook page 14)



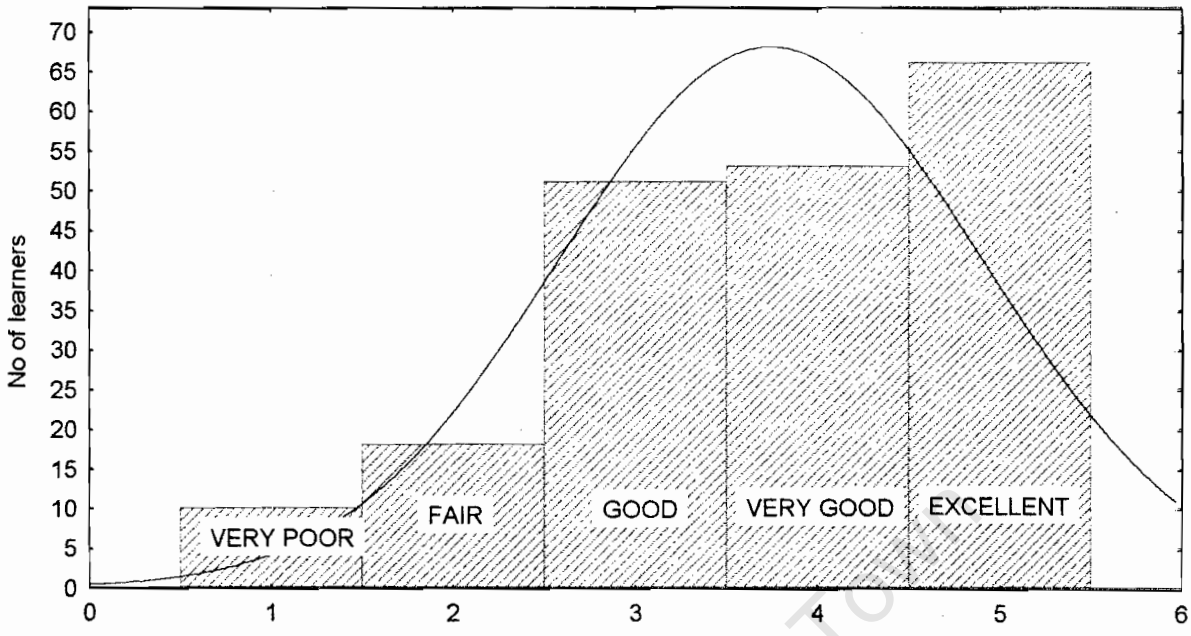
University of Cape Town

Frequency distribution of 166 advantaged learners' ratings
for the illustration sunbird (textbook page 99)



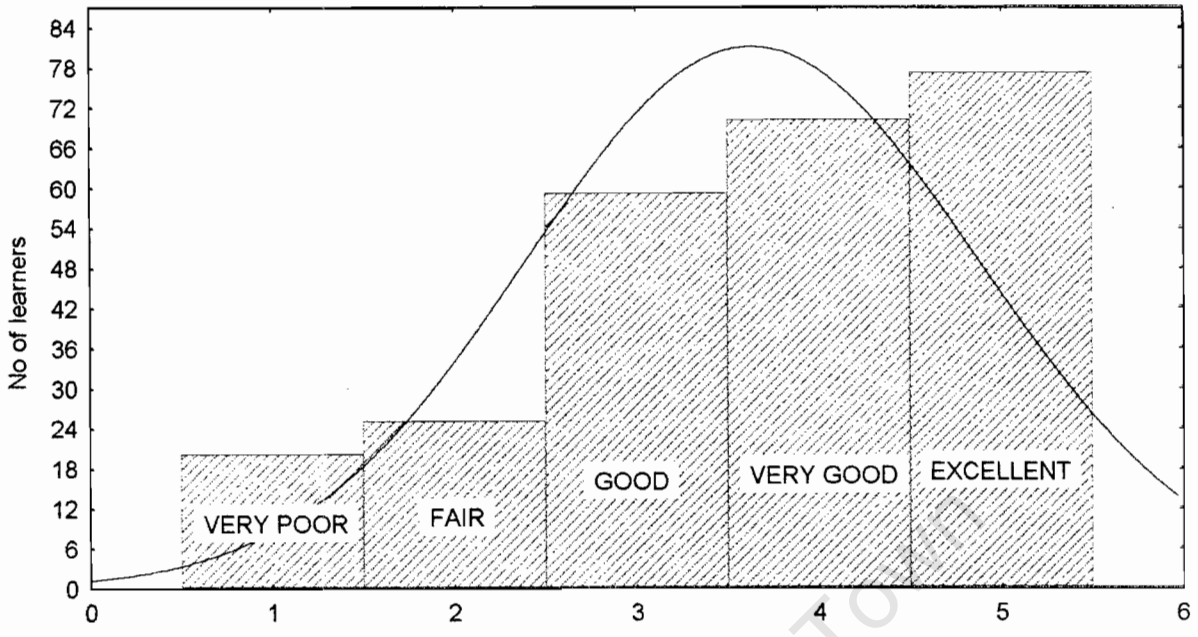
University of Cape Town

Frequency distribution of 200 advantaged learners' ratings
for the illustration water cycle (textbook page 146)



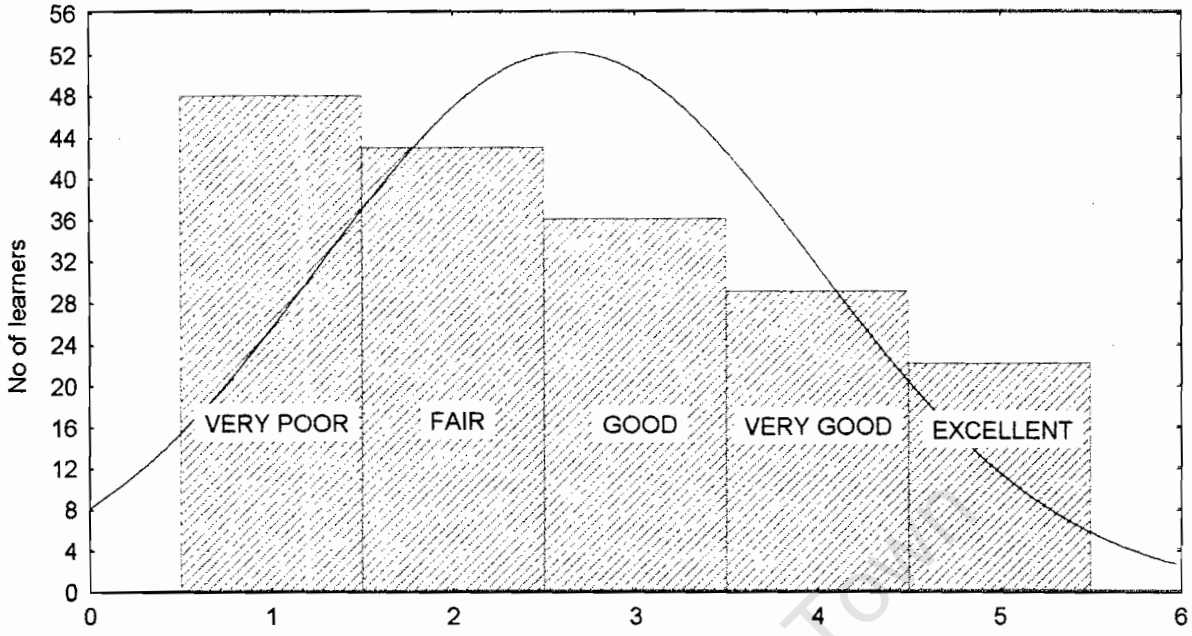
University of Cape Town

Frequency distribution of 252 disadvantaged learners' ratings
for the illustration water cycle (textbook page 146)



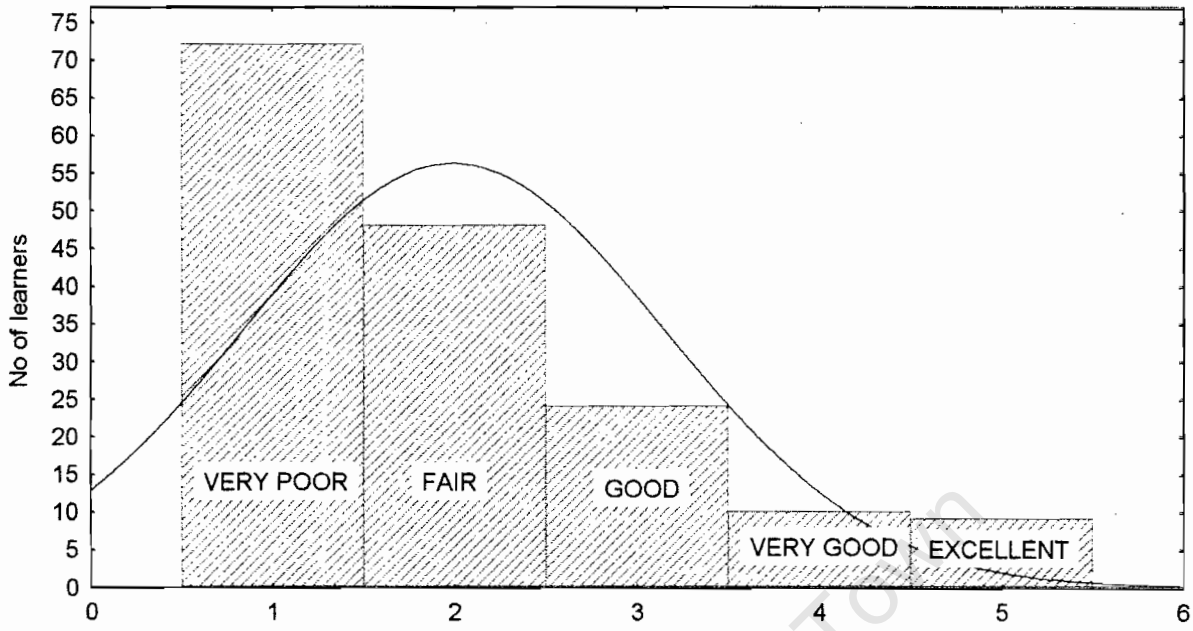
University of Cape Town

Frequency distribution of 178 disadvantaged learners' ratings
for the illustration perlemoen (textbook page 13)



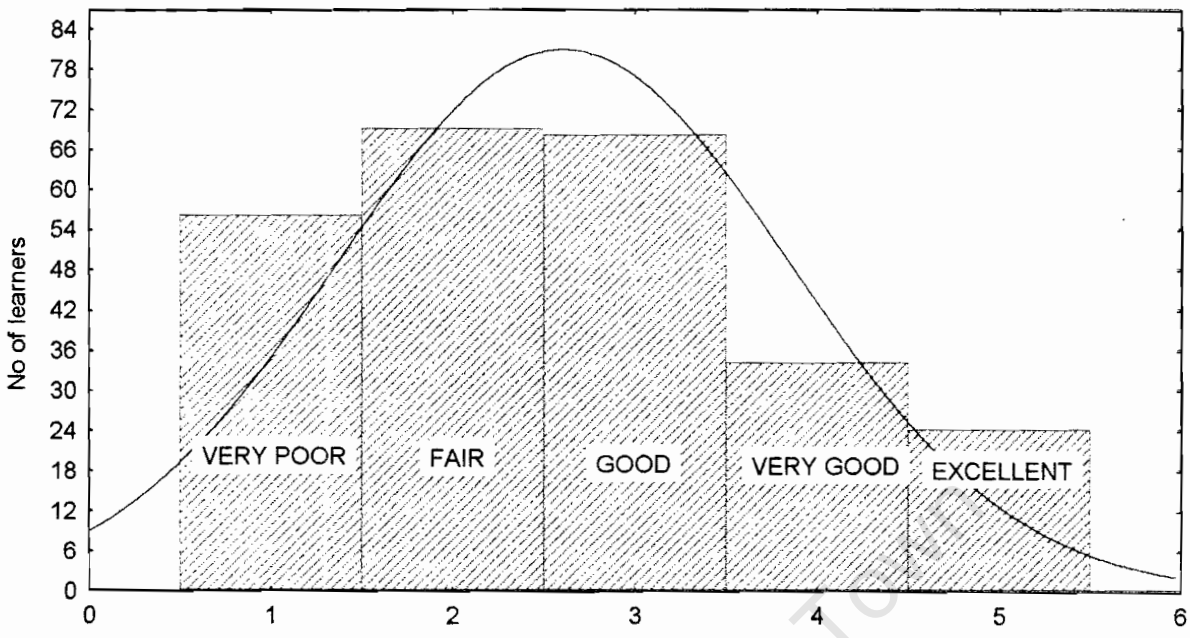
University of Cape Town

Frequency distribution of 166 advantaged learners' ratings
for the illustration chicken (textbook page 100)



University of Cape Town

Frequency distribution of 252 disadvantaged learners' ratings
for the illustration hippos (textbook page 157)



University of Cape Town