GCSE

Biology A

Twenty First Century Science Suite

Teacher Support

OCR GCSE in Biology A J633

Contents

Managing Skills Development and Assessment in Twenty First Century Science

An education in science means different things for different people. The report *Beyond 2000 – science education for the future* [Robin Millar and Jonathan Osborne, eds; King's College, London 1998, ISBN 1 871984 78 5] identified two main purposes for science education at secondary level:

- the first stage in training for future scientists;
- a preparation for life in a modern society for all pupils.

The new assessment structure for GCSE Science in the National Curriculum recognises that these two purposes require courses with different content and different approaches. Thus, the former "Double Award" science, which tried to combine the different purposes into a single course, has been replaced by "Dual Science" – two separate specifications, taught with different aims in view, and leading to two independent qualifications.

The Twenty First Century Science suite of specifications has been designed from the beginning to address both purposes in a way which allows the maximum curriculum flexibility. It provides valid, meaningful and motivating learning experiences for the widest possible variety of students, regardless of interest, ability or career intentions.

The key to this flexibility is provision of a full suite of single subject specifications, which can be combined in many different ways.

The National Curriculum core requirement for science is a minimum of single award science. This must provide a basis of scientific literacy: science for citizenship, for all young people, based on sufficient knowledge of science content to comprehend major issues in modern society.

This coverage is provided through the specification

- Science (J630), which provides an education for all students, based on scientific contexts and issues in contemporary society.

It is anticipated that the majority of students will wish to learn more about science. In this suite, two alternative varieties of Additional Science are offered:

- Additional Science (J631), which extends knowledge and understanding of science to provide a sound basis for more advanced study
- Additional Applied Science (J632), which provides a work-oriented experience of how science is applied in chosen manufacturing or service areas

These three specifications are designed to suit different populations with different needs. Thus, the assessment of skills through coursework is different in each specification and designed to match the different objectives of each specification. Because many students will take one of the additional sciences as well as Science, the assessments for the Additional Science specifications are designed to be complementary to those for Science, not merely to repeat similar activities.

The three schemes of assessment are different, but each is based on activities which should occur as a normal part of teaching and learning in the course. The general procedures followed in awarding, recording and submitting assessment marks follow the same pattern for all of the specifications.

In addition the suite includes single subject specifications in each of Biology (J633), Chemistry (J634) and Physics (J635). These specifications include the relevant subject content from each of Science and Additional Science plus additional content. The skills developed in the separate science qualifications are identical to those developed in Science and Additional Science and this is reflected in the assessment.

An Introduction to Skills Assessment for Twenty First Century Science

Where a centre is introducing several of the schemes at the same time, it may be helpful to ask different staff to ‘lead’ on different schemes, thus sharing out the load of developing new techniques and learning new marking criteria.

The key features of the schemes are summarised in table 1.

Table 1: *Key features of each skills assessment scheme*

specification	Science A J630	Additional Science A J631	Additional Applied Science J632
Abilities to be developed	Responding to science in the media and in society	Practical investigative skills	Workplace skills and activities
Assessment activities	Analysis of first-hand data + A case study of science in the media	A complete practical investigation	Standard procedures + Suitability test + Work-related report

For each separate science subject (J633:Biology, J634:Chemistry or J635:Physics), each candidate may offer:

either: (A229) a case study and data exercise, as for Science

or: (A230) a practical investigation, as for Additional Science

Staff at a centre may decide to allow candidates to carry out both types of activity, thus developing the full range of skills, and then submit whichever gives the higher mark; or to concentrate on just the one type of assessment.

Marking Internally Assessed Work

Strands and aspects of performance

The method of marking the skills assessment is the same across all specifications in this Science suite. The award of marks is based on the professional judgement of the science teacher, working within a framework of descriptions of performance which are divided into **strands** and **aspects**. Within each strand there are different aspects of performance, which in turn have four descriptions of performance illustrating what might be expected from candidates working at different levels.

For example, in the assessment of Data Analysis, Strand I: Interpreting Data

Aspect of performance	Strand I Mark			
	2	4	6	8
(a) graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data-sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations e.g. correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion	Use complex processing to reveal patterns in the data e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.

Each aspect in turn should be considered, comparing the work first against the two mark performance descriptor, then the four mark, then six etc. until the best match is found.

Where performance significantly exceeds that required by one descriptor, but does not sufficiently match the next, the intermediate mark (1, 3, 5 or 7) should be awarded.

Note the implication that performance descriptors indicate the quality of performance required, as distinct from mark criteria which look for mechanical matching and too easily lead to ‘hoop jumping’ for its own sake.

Thus, the level of performance in each aspect is decided. The single, overall, mark for the whole strand is then taken as the best fit to the level of performance shown. This would normally be the average of the levels judged for the individual aspects.

In a few instances, dotted lines on the assessment scheme are used to indicate alternative ways of accessing credit. For example, some work may be best described by graphical display of results, and other work by numerical processing – either can be used as the basis for the mark, allowing a wider variety of different types of investigation to match the criteria. Where it is possible to award some credit under both of the alternatives, the better of the two should be taken as the mark to count.

With these few exceptions, all the aspects must be taken into account in reaching the final mark for the strand. If there is no evidence of achievement for an aspect, a mark of zero should be recorded and included in calculation of the overall strand mark.

Candidates may not always report their work in a particular order, so evidence of achievement in a strand may be located almost anywhere in the work. Thus, it is necessary to look at the whole piece of work for evidence of each strand.

Where a decision is based partly on teacher observation of the candidate at work, the work should be suitably annotated at the appropriate point in the report.

Marking Grids

Marking decisions should be recorded on marking grids. A master copy for Unit A229 is provided in Appendix K. A master copy for Unit A230 is provided in Appendix L. The completed grid serves as a cover-sheet for the work if it is required for moderation.

Within any one strand, each aspect should be considered in turn. A tick on the grid should be used to indicate the performance statement that best matches the work.

When each aspect of performance within a strand has been assessed in this way the pattern of achievement is interpreted by a 'best-fit' judgement to give a mark for that strand. For example,

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
I	(a) graphical or numerical processing of data					✓					5
	(b) summary of evidence					✓					
	(c) explanations suggested							✓			

This method of marking can be applied even where there is a wide variation between performance in different aspects. Thus, weak performance in one aspect need not depress marks too far if other aspects show better performance.

In some cases, in order to allow credit for the widest possible variety of activities, an aspect of performance is represented by two (or more) rows of performance descriptions (for example, graphical or numerical processing in the Strand I example above). In such cases, where a row is not relevant or appropriate for a particular activity, it should be left blank and not included in making any marking decision. If both rows are appropriate then the best mark for that aspect can be used.

Managing the activity in action

During the practical sessions ask what might be called enabling or checking questions to ensure progress for all students, independent of ability.

For example, questions such as

- Can you explain to me your basic method?
- How do you know that the experiment is a fair test?
- How accurate are your measurements?
- How reliable are your measurements?

The aim is to encourage students to reflect on their work and refine their procedure if necessary.

Writing up the activity and marking

During the time period of the activity it is suggested that students write up as they go along and show you the various stages. If the coursework is word processed changes, alterations, and additions can easily be done. If hand written then writing on one side of A4 allows the opportunity to include extra pieces of paper as and when needed.

The teacher should make **general** comments about aspects that are missing or need further development e.g. is your results table complete? is the range of measurements sufficient?, have you drawn a best fit line on your graph?

At the end of the activity a suitable short deadline is set and the work handed in for marking.

The work should not be returned for further re-drafting.

Appendix H includes suggestions of suitable topics for Investigations. Appendix J provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Investigations.

A Rationale for Skills Assessment in Biology A

A229 Case study and data analysis

The National Curriculum Programme of Study specifies that science should be a course to develop scientific literacy. 'Literacy' in any subject area may be described as the ability to comprehend what is written about the subject – to take an informed part in discourse about the subject.

In everyday life, citizens most often become aware of science-related issues through reports in the media: newspapers, teenage magazines, television, etc. Work on this course should help candidates to develop capabilities in evaluating such reports, and the reliability of the evidence they are based on, and to increase awareness of appropriate ways of making decisions about the issues which are raised.

The skills assessment is designed to identify and reward these capabilities. Schemes of work should be designed to build up the skills gradually through suitable activities including study of topics where different views can be considered and compared. Coursework should arise naturally out of teaching, so that it can be assessed by teachers, internally standardised and then externally moderated by OCR. The skills assessment contributes 33.3% to the overall assessment of the specification.

The skills assessment comprises two components: the critical analysis of primary data, and a case study on a topical (scientific) issue.

Data analysis activity

First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome them. The published scheme of work includes many experimental practical activities to ensure that candidates experience how scientific evidence is obtained.

It must be clear that the candidate has been personally involved in generating at least some of the data, but the collection of the data is not directly assessed. This avoids pressure to 'drill' particular techniques simply for assessment purposes. However, it must be clear that the candidate has been personally involved in generating at least some of the data.

The assessment is based on analysis and evaluation of data because these skills are necessary for deciding the merit of scientific claims made in the media, or in support of proposed actions. Analysing and interpreting data illustrates how scientists use experimental evidence to develop and test theories. Evaluating the procedures and data shows how the reliability of scientific findings can be assessed.

The mark-scheme used is identical to the two corresponding strands of the assessment of Investigations in Additional Science and Unit A230.

Case study

The case study is designed to motivate candidates and give them an insight into how science is reported to the public, and to teach them how to assess the validity of underlying research and claims or recommendations based on the research. Ideally, the study should arise from such a media source. Suitable topics involve some degree of controversy, or disagreement, either about the interpretation of the scientific evidence, or about how individuals or society should respond.

The title for a case study is best phrased as a question with a yes / no answer, to be answered by careful balancing of evidence and opinions from a variety of sources.

Arriving at the final mark

The final mark for each candidate comprises the total for one practical data interpretation exercise plus one case-study. It is not permitted to aggregate part-marks from different activities as the assessment covers the candidate's ability to complete a task. Candidates should be given opportunities to develop their skills before completing the assignments for assessment.

Data Analysis (Assessment Unit A229)

Data from observations and measurement are of central importance in the various processes that lead to new scientific knowledge.

Throughout the course, candidates will carry out a variety of practical activities, to illustrate principles and to gather data as a basis for discussion or further work. Any activity in which students are personally involved in generating first-hand data is suitable as a basis for this assessment. Any such activity is also suitable for introducing ideas about quality and reliability of data, and the relationship between the data and how it can be explained.

Whenever data is being collected, attention should be drawn to the quality of the data.

Time should be taken to:

- analyse the data
- evaluate the reliability of the data
- discuss the conclusion
- discuss the level of confidence in the conclusions.

In this way, students will gradually develop familiarity with the terminology used, and the requirements of the assessment marking criteria. Every experiment should be a part of the preparation for this assessment.

The intention of these activities is to give an appreciation of the limitations to data, and develop understanding of accuracy and reliability in data. These are described in the specification as Ideas about Science. This part of the assessment highlights in particular

IaS 1: *Data and their limitations*

IaS 2: *Correlation and cause*

IaS 3: *Developing explanations*

Ideas about Science are described more fully in Appendix N, where they are also linked to performance by a candidate, indicating the level of understanding expected.

The performance criteria used for marking this assessment form two of the five ‘strands’ of a complete investigation as defined in A230.

Many Centres use marks for this assessment from full investigations and in many ways candidates appear to be better placed to make realistic evaluations of their procedures and data collected. However, in the case of weaker candidates, the data collected is often poor in quality and quantity so that they find interpretation difficult. Therefore, in these cases, data collection activities involving whole class participation were generally the most successful. These included pollution surveys, fitness studies and habitat surveys. In these activities, the whole class can be involved in the planning stage. Each candidate takes some measurements, so that they are familiar with the practical difficulties involved. The total body of data collected can be very large, so that there is plenty for students to say about accuracy, validity and reliability.

Guidance in Marking the Data Analysis Task

Marks are awarded for two strands, Interpretation (Strand I) and Evaluation (Strand E). The two marks which make up the assessment total for this element of skills assessment must both come from the same activity.

The full criteria are given in Appendix C.

Strand I: Interpreting data

This aspect of the marking criteria relate to Ideas about Science 1.4, 2.1, 2.3, 2.4, 3.1, 3.3, 3.4.

Aspect (a) Revealing patterns in data

Students should be encouraged to look for patterns or relationships within the data they have available. This is often easier if a substantial amount of data is accumulated.

To save time, a class can share data. Each student or working group can collect a little data, to experience the practical problems involved. Pooling the data makes it easier to look for trends or patterns, or to establish the range covered by 'repeat' readings.

Some activities lend themselves to graphical display of results to give visual indications of any patterns or trends e.g. relationships between variables over a range of values. Others may be more easily analysed by numerical or statistical processing e.g. patterns of species distribution in a habitat. To allow for this, the mark scheme provides alternative sets of performance descriptors (two rows in the table of descriptors, separated by a dotted line). This allows a much wider variety of tasks to give access to the mark range. Where work allows aspects of both, then both should be assessed, and the higher of the resulting marks is taken.

Aspect (b) Summarising the evidence

As part of the conclusion students should be encouraged to give summaries of the patterns they find in their results. For higher marks, the conclusion should be quantitative or based on statistical analysis, and any limitations or uncertainties should be recognised.

Aspect (c) Explaining the evidence

A scientific explanation is a suggestion which involves a plausible mechanism to explain why the results turn out as they do. Students should be encouraged to refer to prior scientific knowledge to support their explanation.

Strand E: Evaluation

Candidates are expected to be able to look back at the experiment they have carried out, show what they have learned from doing it and explain how they would modify it in the light of this, were they to carry it out again.

This aspect of the marking criteria focus on the Ideas about Science 1.1, 1.2, 1.3, 2.2, 2.3, 2.5, 2.6, 2.7.

Aspect (a): Evaluation of procedures

Students review any practical difficulties encountered whilst collecting the data. They also review the extent to which they were able to control factors which might have interfered with their experiments and affected the accuracy or reliability of the data. They then consider whether they could make any improvements in the apparatus, materials or procedures.

Aspect (b): Reliability of evidence

Students review the consistency of the data, for example in respect of the closeness of 'repeat' measurements, or the 'scatter' evident on graphs of the data. They identify any results which appear to be 'outliers' and attempt to explain how these may have arisen.

Aspect (c) Level of confidence in the conclusion

Students consider how secure their conclusion is. This should be related to the precision and reliability of the data, to the adequacy of the ranges covered and, if relevant, whether there are real differences between data sets. They identify any areas of weakness in the data and suggest what extra work might be needed to strengthen these.

Appendix B includes a list of activities which might be used for the teaching and assessment of data analysis and evaluation skills.

Case Studies (Unit A229)

Each candidate entering A229 is required to present one case study, a report based on detailed study of a chosen topic.

The case study is designed to motivate candidates and give them an insight into how science is reported to the public, and how they can explore the validity of underlying research and claims or recommendations based on the research. The case study will draw on the Ideas about Science described in Appendix N.

These assignments should arise naturally from work on the course or from an issue that arises while candidates are following the course. They should be related to an aspect of science that involves an element of controversy, in terms either of the interpretation of evidence, or of the acceptability of some new development.

When should the assessment be done?

Assessment can take place at any time during the course. Some centres may wish to carry out a study early in the course, or at the end of year 9 to introduce the idea of case studies and the marking requirements. This would provide marks which could be counted. However, the course modules are designed to allow regular activities which illustrate and help to develop the necessary skills, so it is generally more effective to delay the assessment until several course modules have been covered.

If the course is being taught over two years, then the second half of summer term in the first year provides a suitable time. For a one-year course, an alternative time may be early in spring term.

Note that internally assessed units can only be submitted for moderation in the June examination season (not January). It is necessary to register for moderation. It is also necessary to notify OCR when unit marks are to be aggregated for award of GCSE certificates.

Some centres have devoted a short period of time entirely to case studies e.g. all science lesson time for a week. Others prefer to spread the task over a longer period. This would require some preliminary discussion with students – perhaps revisiting possible topics from modules already covered, in order to select questions for study. Some students may need to be given topics, but in most cases better motivation is achieved if each student can choose their own question to study. If possible, one or two lessons should be timetabled to give students individual access to the internet. If this is not possible, it will be important to negotiate access to the web for non-contact time e.g. via the school library. Finally at least one lesson, preferably two, should be allocated so that the majority of the final writing up can be done under classroom supervision.

Preparing Students for the Assessment of Case Studies

One main aim of the course is to help students make better sense of science stories or issues they encounter in the media. Most of the teaching modules include examples of issues for students to explore. These provide opportunities to gradually develop competency in

- searching for information;
- acknowledging sources;
- considering the scientific basis for claims or ideas they encounter;

- comparing different views and opinions;
- justifying their conclusion by reference to the evidence;
- presenting ideas effectively.

Format of the case study

Candidates will find it helpful to have a clear sense of audience in their writing – perhaps students in year 9, to encourage them to explain the basic science behind the topic.

Case studies will often take the form of a 'formal' written report. However, candidates should not be discouraged from other styles of presentation, for example:

- a newspaper or magazine article;
- a PowerPoint presentation;
- a poster or booklet;
- a teaching/learning activity such as a game;
- a script for a radio programme or a play.

In all cases, sufficient detail must be included to allow evaluation in all of the performance areas. Some types of presentation would require supporting notes to explain the choice of reporting medium chosen.

Choice of topic for a case study

Topics for study should be selected by candidates in discussion with teachers, and should be seen as an extension or consolidation of studies undertaken as a normal part of the course. The work should be capable of being completed within approximately 4-6 hours over a period of time, for example, one lesson per week for half a term, with some non-contact time.

Suitable topics often fall into one of three main types:

- Evaluating claims where there is uncertainty in scientific knowledge (e.g. “Is there life elsewhere in the Solar System?”) Controversies of this type focus attention on the relationship between data and explanations in science, and on the quality of research which underlies competing claims.
- Contributing to decision making on a science-related issue (e.g. “Should the government restrict research into human cloning?”) Studies in this category are more likely to involve elements of personal choice, values and beliefs, and may involve balancing of risks and benefits of any proposed action.
- Personal or social choices (e.g. “Should my child receive the triple MMR vaccine?”). Ethical and personal issues are likely to figure in such studies, but it is important to evaluate these in relation to what is known about the science which underlies the issue.

In all cases, an important factor in choice of subject should be the availability of information giving a variety of views in forms that can be accessed by the candidate. Candidates may be provided with the initial stimulus for the study, but should be encouraged to search for a range of opinions in order to reach a balanced conclusion.

The subject need not be restricted to topics studied in the course. However, it is necessary for the candidate to apply some relevant scientific knowledge and understanding to discussion of the issues raised. This is most likely to be the case if the study arises naturally during normal work on the course.

Candidates need not all study the same, or related, topics. Motivation is greatest if they are given some degree of autonomy in the choice of topic. This may be achieved by allowing choice of different issues related to a general topic or by encouraging candidates to identify topics of interest and begin collecting resource materials over an extended period. At a time chosen by the centre, candidates then complete their Case study, and may each be working on a different topic.

The assessment might be introduced in a lesson which reviews controversial topics in modules already studied (e.g. issues related to GM foods or cloning in You and Your genes, etc). This might also include a look forward to issues which will be met in later modules, especially if these turn out to be topical in the media at the time. Students can then choose the area of greatest interest to themselves, and define a question to address within that topic.

This initial lesson should at least define the questions to be studied, and if possible provide some initial ideas for sources of information.

It is then very helpful if one or two lessons can be time-tabled in a library or computer room, so that pupils can continue to research additional information with some supervision and help from staff.

Finally, one or two lessons should be provided when pupils can complete the majority of their writing-up under supervision (to avoid plagiarism or sharing of work).

Some centres prefer to provide these as successive lessons, completing the whole task within a week. Others prefer to spread them out, say one per week over 4/5 weeks. In either case, it should be remembered that this is **coursework** and so should be done within course time. The centre should provide the lesson time, supervision and support which is needed.

The total amount of class contact time required should be about 4 – 5 lessons.

Several of the teachers who took part in the pilot have contributed activities which help to develop case study skills. Jim Beresford, of Fartown High School has used a variety of activities:

- Distribute newspapers round the class (the free "METRO" is often a good source of science-related stories). Ask each group to find headlines which are 'science-related'. When headlines are read back, encourage class discussion to identify which bits of science knowledge are linked to the story.
- Find a science-linked story in a paper. Distribute copies together with an activity to focus on the text e.g. highlight science claims or theories in green, supporting evidence in blue, opposing views in red. Then discuss how reliable the opinions in the article seem to be.
- Provide media stories as stimulus. Ask each student to generate two or three questions which could be answered as a case-study. Collect and display suggestions then prompt discussion of how suitable, or easily managed, each might be.
- Provide copies of (anonymous) case studies from other classes or previous groups and 'pupil-speak' versions of the marking criteria. Ask each group to mark the case-study, then discuss the marks awarded and the good or weak features of the study.

Appendix D includes suggestions of topics studied by students in pilot schools. Appendix E provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Science coursework.

Guidance in Marking Case Studies

A case study represents a major piece of work and it is not expected that students should attempt more than one full study during the course. If a student attempts more than one case study, then the mark for the assessment should be based on the highest-scoring single study. It is not permitted to aggregate marks from two or more different pieces of work, nor to add together marks taken from separate, limited range tasks, exercises or part studies.

Because of the risk of some studies becoming excessively long, it is important to link marks to the quality of the work done, rather than the quantity.

Appendix K shows the sheet used for recording the marks awarded which count towards the final assessment total. When work is selected as part of the sample for moderation, the work of each candidate in the sample should have one of these forms completed and attached as a cover-sheet to the work. The sheet will be used as a working document by the moderator.

Strand A: Selecting information

Where possible, students should use multiple and different types of sources of information e.g. web-sites, encyclopaedias, library books, course textbook and their own notes. There should be a list of the sources used and these should be detailed referring to, for example, book and page number and full URL, not just to the homepage of the particular website.

Material from the sources should be selectively used, not just a collection of 'cut-and-paste' extracts. This will usually include some direct quotation, but should also involve some re-structuring and comment on the information. Where sections of text are directly quoted, this should be made clear e.g. quote-marks or different font from the main body of the text if word processed.

To score well in this strand, students must link information in the report to the sources used and evaluate the quality of the sources, recognising any discrepancy between sources.

Strand B: Quality of scientific understanding

Students should show their understanding of the background scientific knowledge and understanding which will help them evaluate the information in their sources. Students should explain the basic scientific facts, principles and concepts of the topic and their student textbook or own notes will be a good source. This can be backed up by extra information from more advanced or specialist books, encyclopaedias or web-sites.

It is often helpful, before marking begins, to think about what would represent excellent, good, fair or poor performance in each aspect for the particular title chosen by each student. This is particularly important in marking strand B.

The first aspect of strand B requires students to use scientific knowledge and understanding to provide a background for the study. This must be interpreted in relation to the knowledge available to the student through studies already completed on the course, together with what might reasonably have been found from the sources available for the study.

Most current science issues are likely to extend well beyond the limits of GCSE science. It should be made clear to students that they will not be required to recall any of this extra theory in their examinations. However, they will find it helpful to look up science knowledge beyond what they have done in lessons to help them understand the topic they are studying. Many students respond very positively to the experience of finding that they are able to follow a topic beyond the limits of what has been presented in class.

Marking trials during the pilot were used to develop agreement about the levels of science to be expected. The following examples were developed by pilot teachers as a result of marking work done by their pupils.

Case study title	Related science knowledge and understanding
Who is to blame for obesity?	what is a balanced diet major and minor nutrients respiration, metabolic rate, and fat storage health problems associated with obesity ‘junk food’, publicity and social pressure combined effects of exercise and diet
Should we add fluoride to water?	fluorine as a group 7 element; fluorides evidence for the effect of reducing tooth decay harmful or side effects alternative ways to administer fluoride opting in or opting out ethical issues related to compulsory medication

This sort of preliminary survey of a topic allows markers to develop judgement about the amount of science which would be expected at each mark level.

The second aspect of strand B requires students to recognise and evaluate the scientific basis of any claims they find in their sources – how much if any research was done, how clear and relevant are the results? Successful studies will show a critical approach to judging the reliability of the claims which are reported.

Strand C: Conclusions

There should be evidence that the sources used have been compared to check for consistency and to identify areas of conflict or disagreement. There should also be evidence that the underlying science has been used to try to resolve any differences.

There should be evidence that points ‘for and against’ have been compared and that candidates have given their own viewpoint or position in relation to the original question, and have justified this by reference to the sources.

Strand D: Presentation

Communication skills should be rewarded for effective presentation including use of different forms for presenting different types of information (e.g. pictures, tables, charts, graphs, etc.).

Suitable diagrams and graphics should be incorporated as appropriate to clarify difficult ideas and encourage effective communication. A table of contents gives structure to the report and also helps to guide readers quickly to particular sections.

Reports which are presented as PowerPoint should include notes to accompany each slide, enabling student to access the higher mark descriptions across other strands.

Appendix C shows the marking criteria for case-studies.

Appendix F gives marking commentaries for the example case-studies.

A230 Practical Investigation

This Biology specification is designed so that, when taught along with Physics and Chemistry, it will provide a suitable foundation for further studies of science. It is most suitable for candidates with an interest in becoming professional scientists, or for those who, in addition to understanding how science works, want to learn more about scientific facts and principles and the experimental work that they are based on.

In scientific research, investigations play an important part, especially those based on experimental work under carefully controlled conditions. Over the past 20 years, investigative work has increasingly formed the basis for coursework assessment in school science courses, as well as being a powerful teaching and learning process.

The use of practical investigations to assess skills in school science was based on work done by the APU, and research in a number of centres, particularly the University of Durham. For more than 10 years, it has formed the basis of coursework assessment for GCSE science.

Investigations require the drawing together of skills in planning, collecting data, interpreting data and evaluation. They provide an effective and valid assessment instrument for a course which is seen as a basis for further studies and possible future careers in science.

However, the assessment of investigations in the National Curriculum has led to an ever narrower range of activities being used, and to rather mechanical ‘criterion matching’ rather than genuine open-ended work. For this specification, the basic structure of investigations is retained, but the emphasis on prediction is removed, allowing a much wider range of activities and approaches. A different marking style, drawing more on professional judgment of teachers has also been developed. Rather than “mark criteria” which imply a formal, standard matching, we prefer the term “performance descriptors” which indicate the type and quality of performance expected at each level.

The coursework aims to motivate candidates and help them to appreciate the importance of having a clear and manageable question, to learn how to choose equipment and use it appropriately, and to design suitable apparatus for making observations and measurements. First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, and a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome these.

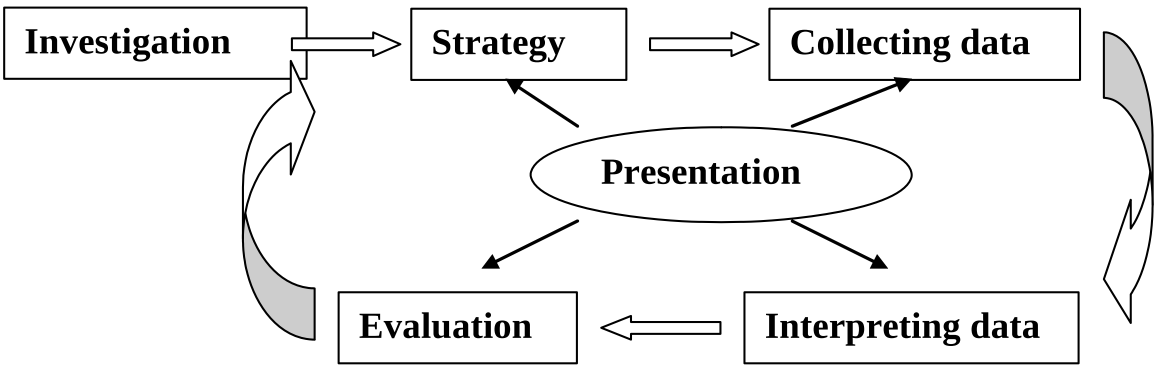
The changed approach to planning investigations is designed to avoid over-direction of students using given standard procedures. Hence, there is an increased emphasis on the autonomy shown by the student in considering factors to be controlled, and in preliminary testing to establish suitable conditions for the investigation.

Summary of differences between assessment of investigations in established GCSE courses (Sc1.2) and in 21st Century Science courses.	
Former GCSE Courses (Sc1.2)	Additional Science A
Planning must be based on use of prior knowledge of relevant theory. This restricts access except to a small number of topics.	Students devise a strategy to ensure adequate, good quality evidence. Activities may be based on theory provided for them or may be exploratory.
Only studies across a range of values of a test variable can easily match the criteria.	Comparisons, distribution surveys or tests of reliability can also match the mark descriptors.
Investigations may be based on first hand or secondary evidence (e.g. simulations or web-searches).	Investigations must include collection of some first-hand practical evidence.
Individual marks for different skill areas may be collected from different activities and aggregated.	The final mark is the total for the best single piece of work.
Mark criteria must be matched in particular order, leading to mechanical 'hoop-jumping'.	Performance descriptors allow 'best-fit' marking using professional judgement over a range of aspects of the work.

Presenting and marking investigations

The type of investigation used for this assessment is developed from those used in GCSE assessment for the past 10 years. This model in turn, was developed from work of the Assessment of Performance Unit in schools. The advancement of science knowledge and understanding through investigations is seen as a cyclic process – as each investigation progresses it becomes possible to review the progress made so far, and the results of each investigation inform the planning of the next.

In this model, the whole process of an investigation is made up of four stages – formulating the idea and deciding what to do, carrying out the work to collect the evidence, making sense of the evidence, and finally evaluating the whole process, either as a summation of the work, or in preparation for the next investigation.



We have retained this basic structure. However, assessment over the past few years has attached particular meanings to the labels used in Sc1, and now the emphasis is changed, so we have chosen new labels to allow a fresh approach. We have also added a fifth strand to the assessment, which provides credit for effective communication through the investigation report.

The five strands which make up the assessment are:

Strand S: Devising the strategy

Strand C: Collecting the evidence

Strand I: Interpreting and explaining the evidence

Strand E: Evaluating the evidence and the procedures used

Strand P: Presenting a report of the investigation

The full criteria are given in Appendix G.

Strand S: Devising the strategy

It is expected that normal teaching will have established the context for any investigation and have developed understanding of the underlying science. The task for the student is to decide how much evidence, and what quality of evidence will be needed to solve the problem or answer the question, and to select the most suitable equipment and procedures.

Students are no longer expected to predict the answer before they begin, so high marks are not restricted only to studies where suitable explanatory theory is available. This is intended to allow work on e.g. species distribution, behaviour patterns, or quality control to match the criteria.

In recent years, too much work in Sc1 has become simply using carefully-drilled standard procedures. Here, successful students will show some independence or autonomy in selecting the best ways to proceed and in deciding how much evidence to collect. Those who are less able to work in this way may be given guidance, or even provided with standard procedures to follow, but this will reduce the maximum mark they can access in this strand.

It is advised that more time should be made available for the planning stage than has been usual in the past. This should allow students to explore the background to the task, establishing what factors may be important and how to control or allow for them. It should also allow them to consider different approaches, and to carry out preliminary tests to establish suitable ranges to cover.

For example, in an investigation of osmosis, students could explore a variety of variables, including the concentration of solution, size of piece of vegetable, type of vegetable and temperature. Help in devising suitable strategies should be given where students need it, but this reduces the mark which can be given for “autonomy”. The level of help given to each student should be recorded.

The necessary skills can be encouraged whenever practical work is undertaken by allowing time for class discussion step-by-step as the work is planned, and linking this to the amount and quality of evidence which will be obtained as a result.

Strand C: Collecting evidence

In this strand, the assessment is not simply based on the data which is reported. Valuable indications can also be obtained from the detail given in the strategy, where students show their awareness of factors which might affect the results. Indications of the quality of the work can also be found by looking at graphical displays to see the quality and consistency of the final data.

Both students and markers should be encouraged to look at the quality of individual raw data, and the level of agreement between repeat readings, as well as looking at the overall pattern of results.

Strand I: Interpreting results

Three aspects of performance are considered:

- revealing patterns of behaviour in the data
- summarising or describing these in words

- explaining the patterns found

The first aspect allows alternative approaches. Much work is best displayed graphically. Some may be better described by suitable numerical processing. The scheme allows either approach to score.

Simple charts or histograms can be credited in the lower mark ranges. Line graphs with lines of best fit can score up to 6 marks (as previously in Sc1). To access 7 or 8 marks, something extra is required. The course places great emphasis on the quality of data. Progression to 7 or 8 marks may come from an indication of the underlying quality and reliability of the raw data (e.g. plotting all raw data in a 'scatter-graph' with a single line of best fit, or use of error bars) or display of multiple data-sets on common axes, or use of more complex data display formats.

The remaining two aspects spread the marks more widely than the former Sc1 criteria. In Sc1, a general statement of a trend scores 4 marks, and this can rise to 6 if supported by some scientific explanation. In these new regulations, the quality of the conclusion must improve for 6 marks, being more detailed and/or mathematical. In Sc1, no explanation was required until the 6 mark stage. Here, some attempt at explanation is required at all levels.

In Sc1, marks below 4 for this strand were very rare. In the pilot scheme, marks below 4 were more common. This provides a better spread of marks to allow more reliable grading, but teachers should be aware of the need to encourage clear conclusions and explanations to improve scores in this strand.

Strand E: Evaluation

There is a high level of continuity here from skill area E of Sc1. Students tend to consider their data separately from the procedures they used to obtain it. The final aspect encourages them to bring these two together as a basis for some overall judgement of reliability, and to think about what extra work might help to further improve the reliability. As with Sc1, the intention is NOT to simply suggest other, related investigations that might be done instead!

Strand P: Presentation

Scientific investigation reports should contain sufficient detail to allow later workers to repeat the experiments if necessary. Thus the method used should be described in detail, including explanations of why particular methods, equipment or test ranges were chosen. Reports should also provide full detail of all data obtained, and of any fixed parameters (e.g. concentrations of stock solutions, etc). Finally, reports should be clear and grammatically correct.

Managing the Assessment of Investigations

Sufficient coursework must take place under direct supervision to allow the teacher to authenticate each student's work with confidence.

There is a potential conflict between the normal role of teacher and that of someone who has to make an assessment of their students' work for an external public exam. Naturally different teachers vary in their procedures and the amount of help and guidance they give but a significant variation can cause uncertainty and it is essential that our students see that each teaching group is being treated uniformly.

The following guidelines represent a broad approach to the subject of managing internal assessment that should help to alleviate significant differences without affecting the autonomy of teachers.

Helping students to develop investigative skills

Every occasion when class practical work or a practical demonstration takes place provides an opportunity to demonstrate and discuss aspects of relevant investigative skills. Time should be taken to build up the design of any experiment or demonstration through class discussion – "What's the best way to measure this?", "How many times should I measure it?"

Students should also be involved in discussing what can be deduced from results obtained, and in looking for weaknesses in the evidence collected, or ways of improving procedures.

Essential preparation for the assessed task

- Choose a task appropriate to the ability of the set or to the development stage they are at.
- Ensure that the necessary scientific knowledge, practical/research skills have been covered.
- Ensure that the students are familiar with and understand the assessment criteria from first hand experience in a non-assessed situation.
- Circulate and discuss the departmental prompt/guidance sheets.

Introducing the activity

The essential aim is to encourage students to ask questions and put forward tentative ideas and suggestions. The teacher should aim to promote discussion without giving specific answers to direct questions to prevent blocking potential avenues of investigation. The teacher can give ideas about resources, reminders about relevant theory etc., and can steer the lesson to a particular title of task if appropriate. This might be done, for example:

- by a teacher demonstration/video/computer simulation
- from questions arising from a class discussion
- from a brainstorming session with the class
- by referring to the knowledge and skills gained from a previous lesson

Managing the activity in action

During the practical sessions ask what might be called enabling or checking questions to ensure progress for all students, independent of ability.

For example, questions such as:

- Can you explain to me your basic method?
- How do you know that the experiment is a fair test?
- How accurate are your measurements?
- How reliable are your measurements?

The aim is to encourage students to reflect on their work and refine their procedure if necessary.

Writing up the activity and marking

During the time period of the activity it is suggested that students write up as they go along and show you the various stages. If the coursework is word processed changes, alterations, and additions can easily be done. If hand written then writing on one side of A4 allows the opportunity to include extra pieces of paper as and when needed.

The teacher should make **general** comments about aspects that are missing or need further development e.g. ‘Is your results table complete?’ ‘Is the range of measurements sufficient?’, ‘Have you drawn a best fit line on your graph?’.

At the end of the activity a suitable short deadline is set and the work handed in for marking.

The work should **not** be returned for further re-drafting.

Appendix H includes suggestions of suitable topics for investigations. Appendix J provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Investigations.

Management and Administration of the Skills Assessment

The scheme of skills assessment is designed to award credit for capabilities which are developed as part of the normal teaching and learning process through the course.

In order to achieve this, schemes of work should:

- make pupils familiar with the assessment requirements and the marking criteria
- present activities in ways which emphasise aspects of the assessable skills
- Identify activities which will be suitable for formal assessment

The overall aims of the course include teaching the ability to assess the quality of scientific data, and of forming critical judgements about issues of public or personal policy which involve science-based decision-making. An important aspect of this is to provide regular activities involving these skills.

Record-keeping

Many practical activities throughout the course could provide evidence for assessment. Teachers may wish to award marks and record these, either as evidence of pupil progress or as a 'fall-back' source of marks if a more formal assessment later in the course is missed or not well done. The final mark submitted must come from either one investigation or one case study and one data analysis task, and evidence for this must be kept safely.

Appendix K and Appendix L provide master copies for the cover-sheets which should be kept with the marked scripts following assessment. It has spaces in which all marking decisions can be recorded as the work is marked. The sheet is then attached to the pupil work. If the work is later required for moderation, the pupil scripts and cover sheet are simply taken from the store and posted to the moderator. The cover sheet will be used by the moderator when checking the marks for the work. It will be retained by OCR as a complete record of all marking decisions made by both the centre and the moderator.

Internal Standardisation of Marks

It is the responsibility of the centre to make sure that the rank-order of pupils is secure. This requires that all work is consistently marked to the same standard.

Appendices F and I provide examples of completed case-studies and investigations with commentaries to explain the mark decisions. These can be used as a focus for discussion between all staff involved in the marking, to exemplify standards.

Internal standardisation should also be carried out. Some or all of the following procedures may be found to be effective:

- one member of staff moderates samples from all markers, thus providing a single reference standard for all
- copies of scripts are passed round for marking agreement trials at department meetings (it is essential that this is accompanied by discussion of reasons for any disagreements)

- a common approach to marking, or customised mark-scheme can be devised and agreed by all markers
- for data analysis or investigations, all scripts from all classes for the same activity, can be marked by one marker
- scripts from one cohort, which have been part of external moderation samples, can be kept and referred to, to help in carrying forward consistent standards from year to year

OCR provide a free consultancy service. As part of this, centres can send in up to three marked scripts and receive feedback on their marking standards.

External Moderation of Marks

After work has been marked in the centre, a sample of the work will be checked by an external moderator. The purpose of this is to ensure that the activities used are appropriate and match the specification requirements, and that the marking standards used in the centre are consistent and in line with national standards.

Shortly after entries are submitted for the skills assessment, OCR will provide form MS1 (mark-sheet) and instructions for what must be submitted from the centre (Appendix O). The mark sheet is in three layers and is self-carboning. The top copy is sent to OCR and will be used to enter raw marks on the computer. The second copy is sent to the moderator. The third copy is kept by the centre as a record.

The moderator will ask for the work of a sample of candidates. The work which counts towards the final total must be sent, together with information which shows what activities were used and how they were presented to pupils. In a few cases, the moderator may ask for further work or information to be sent.

The work will be returned, and a moderator's report will be sent to the centre when results are published. This will provide a commentary on the work seen. In the past, marks from the majority of centres have been in line with standards and have been accepted without change. Where any change has been required, this will be clearly stated and an explanation of the reasons for any changes will be given.

Authentication of Students' Assessed Work

Overall authentication

Samples of work sent for moderation must be accompanied by a signed copy of the centre authentication form. Staff involved in the assessment sign this form to certify that the work presented is the authentic work of the individual candidates.

Data analysis

This assessment awards credit for interpretation and evaluation of data. It does not credit planning the experiments, or carrying them out to obtain the data.

It is necessary for each candidate to be involved in gathering at least part of the data first-hand. Thus, it is not acceptable to base these assessments on data entirely made up, or taken from a simulation or a secondary source.

Candidates may work in pairs or groups when collecting the data. Data may be pooled from whole classes or year-groups in order to provide a sufficiently large body of data for candidates to address issues of reliability or range. Provided that some direct experimental data is included this may be supplemented where necessary with secondary data, but the main intention of this assessment is that candidates should be aware through their own experience of how the data was collected.

The interpretation and evaluation must be carried out by each candidate working individually.

Case studies

The case study is essentially an individual activity. In no case should candidates work together when collecting information. If it is felt that a particular study would benefit from some degree of joint work or collaboration, or from a joint presentation, the moderator consultancy service should be used in advance to obtain guidance on the acceptability of the collaboration.

Investigations

The investigation is an individual activity where the candidate has carried out a whole investigation.

Candidate authentication

Candidates should complete an authentication statement as a cover sheet for their work, a master copy of this can be found in Appendix P.

Appendix A: Marking Criteria for Data Analysis (A229)

The marking criteria used are taken from the marking of investigations. They cover strand I (Interpretation and explanation of results) and strand E (Evaluation).

Thus, the marking of these exercises provides a comparison of standards between those submitting the Case Study and Data Analysis and those submitting an Investigation. Where a candidate has carried out a complete Investigation, this will provide the marks and evidence for this component thus avoiding duplication of assessment and reducing the overall assessment burden.

Within each strand, different aspects of performance are identified. Achievement related to each of these is assessed, and the professional judgement of the teacher is then used to award an overall mark out of 8 for the strand.

Strand I: INTEPRETING DATA (I)

Each row represents increasing achievement in a different aspect of performance.

Within each row, the statements should be used hierarchically. Tick the highest level statement which can be matched by the work done. Intermediate awards (1, 3, 5 or 7) are made where performance exceeds one defined level but does not fully match the next. The mark (0-8) awarded for this strand should be a 'best-fit' from the overall pattern of statements matched.

In some cases, in order to allow credit for the widest possible variety of activities, an aspect of performance is represented by two (or more) rows of mark descriptors. In such cases, where a row is not relevant or appropriate for a particular activity, it should be left blank and excluded from the 'best-fit' marking judgement and the more appropriate alternative row used.

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations (e.g. correct calculation of averages from repeated readings).	Use mathematical comparisons between results to support a conclusion.	Use complex processing to reveal patterns in the data (e.g. statistical methods, use of inverse relationships or calculation of gradient of graphs).
b summary of evidence	Note differences between situations/ cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or 'common sense'.	Relate the conclusion to scientific ideas/ explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

Aspect of Performance	Strand E Mark			
	2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree or scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any anomalies.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions.	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusion more secure.

Appendix B Activities Which Might be Used for Teaching or Assessment of Data Interpretation and Evaluation Skills

Science

B2 Keeping healthy

Growing bacterial cultures in neutral and acidic pHs

Effect of exercise on pulse rate

B3 Life on earth

Investigate the distribution of species in one or more habitats, e.g. to build up a picture of the interactions between different species, or investigating the effect of environmental factors on the distribution (fieldwork)

B4 Homeostasis

Investigate the factors affecting osmosis of sugar solution in potatoes.

Investigate the effect of wind-chill on heat loss.

B5 Growth and development

Investigate cell division in different plat tissue samples

B6 Brain and mind

Investigate factors affecting response times

B7 Further biology

Monitor the levels of carbon dioxide and oxygen exchanged between a plant and the surrounding atmosphere during a 24 hour period

Appendix C: Marking Criteria for Case Studies (A229)

A	1 mark	2 marks	3 marks	4 marks
Planning the use of sources of information	Very little information is given beyond that provided by the original stimulus material.	Information from a limited range of additional sources is included, although some may be irrelevant or inappropriate to the study.	Relevant information is selected from a variety of sources.	Sources of information are assessed for reliability as a basis for selection of relevant information from a wide variety of sources.
Acknowledgement of sources used		Sources are identified by incomplete or inadequate references.	References to sources are clear, but limited in detail.	References to these sources are clear and fully detailed.
Linking information to specific sources		Direct quotations are rarely indicated as such.	Direct quotations are generally acknowledged.	The sources of particular opinions are indicated at appropriate points in the text of the report.
B	**2 marks**	**4 marks**	**6 marks**	**8 marks**
Making use of science explanations	Only superficial mentions of science explanations, often not correctly applied to the case	Provides a basic outline of the main scientific ideas which are relevant to the case.	Provides a detailed review of the scientific knowledge needed to understand the issues studied.	Considers how different views described in the study can be supported by detailed scientific explanations.
Recognition and evaluation of scientific evidence	Sources are uncritically quoted without distinguishing between scientific evidence and unsupported claims.	Science content and data in sources is recognised.	Claims and opinions are linked to the scientific evidence they are based on.	The quality of scientific evidence in sources is evaluated in relation to the reliability of any claims made.

C	2 marks	4 marks	6 marks	8 marks
Comparing opposing evidence and views	Information is unselectively reported without taking any clear view about any course of action.	Claims for a particular idea, development or course of action are reported without critical comment.	Claims and arguments for and against are reported, but with little attempt to compare or evaluate them.	Details of opposing views are evaluated and critically compared.
Conclusions and recommendations	A conclusion is stated without reference to supporting evidence.	A conclusion is based on evidence for one view only.	Some limits or objections to the conclusion are acknowledged.	Alternative conclusions are considered, showing awareness that different interpretations of evidence may be possible.

D	1 mark	2 marks	3 marks	4 marks
Structure and organisation of the report	The report has little or no structure or coherence, or follows a pattern provided by worksheets.	The report has an appropriate sequence or structure.	Information is organised for effective communication of ideas, with contents listing, page numbering etc. as appropriate to aid location of key elements.	Considerable care has been taken to match presentation and format to present issues and conclusions clearly and effectively to a chosen audience.
Use of visual means of communication	There is little or no visual material (charts, graphs, pictures, etc) to support the text.	Visual material is merely decorative, rather than informative.	Visual material is used to convey information or illustrate concepts.	Pictures, diagrams, charts and or tables are used appropriately and effectively to convey information or illustrate concepts.
Spelling, punctuation and grammar	Spelling, punctuation and grammar are of generally poor quality, with little or no use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are of variable quality, with limited use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are generally sound, with adequate use of appropriate technical or scientific vocabulary.	The report is concise, with full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

Appendix D Suggestions for Topics for Case Studies

Developing the skills for case studies

These activities make it possible to develop and practice the techniques which will lead to successful case studies. They provide opportunities to introduce the marking criteria which will be used for assessment.

In the module *You and Your Genes*, students study Huntington's disease to show how ethical considerations are important in genetic counselling. They can be introduced to the use of search engines to trace information on the internet and taught how to acknowledge sources. Related topics include studies of the acceptability of pre-implantation genetic diagnosis, or therapeutic cloning, or GM crops.

Successful Topics for case studies

B1: You and your genes

Should gene therapy be allowed?
Should gene therapy be allowed to prevent Huntington's disease?
Human cloning – should it be banned?
Designer viruses – good or bad?
Is genetic testing ethically right?

B2: Keeping healthy

MRSA – is hospital the best place when you are ill?
Antibiotics – is there a crisis?
How safe is MMR vaccination?
Is animal testing justified?
Should cannabis be used as a medical drug?
Does MMR cause autism?
Are edible vaccines best?
Should DDT be banned?

B3: Life on earth

Creation or evolution?

B4: Homeostasis

Should ecstasy be readily available?

B5: Growth and development

Should human cloning be allowed?
Should we produce designer babies?
Is cloning the way of the future?

B6: Brain and Mind

Can brain exercises really keep you young?

B7: Further Biology

Should GM crops be grown in Britain?
Who should have access to medical records?

Appendix E: Guidance for Students Writing a Case Study

We live in a developing technological age. People in governments, industry and other institutions have to make decisions that can have a significant effect on our lives. Newspapers, journals, television and other forms of media often report science-related stories where there is some disagreement about how we should react.

In doing your case study, you will learn how to find out what a variety of different people think about the story you have chosen, and how to use your science knowledge to reach a balanced judgment about how to respond.

Choose a story which interests you and where you can find enough information from people with different points of view. The title for your case study is probably best as a question that you can answer by balancing evidence and opinions from the information you have gathered.

Assessment

The case study will be marked, and this contributes 20% to your final GCSE grade so it is worth putting some effort into this activity. It could have a significant effect on your final grade. However, do not make your report too long as it is quality not quantity that counts!

Your teacher will mark your case study under four main headings:

A How good was your research:

- How did you find the story?
- Have you looked for more information from other sources?

B Do you understand the science:

- Have you described science ideas which help you to understand what is important in the study?
- Have you checked what science data or ideas are used in the articles you looked at?

C Have you compared different views and formed a conclusion?

- Have you considered arguments for and against?
- Have you thought about the risks and benefits of the action that is suggested?
- Have you said clearly what you think (and why)?

D Have you presented your report in an attractive and interesting way?

- Is the report well-organised so that it is easy to follow the story?
- Are your spelling, punctuation and grammar correct?
- Have you used pictures, charts, tables, graphs or explanatory diagrams to help make information easier to understand?

A Quality of selection and use of information: (maximum 4 marks)

- You should use different types of sources of information that contain relevant information for your case study e.g. course book, web-sites, library books and your own notes.
- Give a list of the sources used and these should be detailed referring to, for example, book and page number and full website address not just to the homepage of the website.
- Material from the sources should be selectively used, not just a collection of 'cut-and-paste' extracts. This will usually include some direct quotation, but should usually also involve some re-structuring of information.
- In the body of the report, make it clear where each particular piece of information came from e.g. "The Daily Mail of 21st Sept said…" or "these results came from Prof X. Smith at the University of …."
- Where sections of text are directly quoted, this should be made clear e.g. quote-marks or italic script. This allows the reader to see which source a particular claim or piece of information has come from.
- At the 4 mark level, any obvious disagreement between sources should be recognised.
- It is important to say how reliable you think each of your sources is. This is particularly important for data from web-sites, which vary widely in the reliability and authority of the opinions expressed.

B Quality of Understanding of the Case: (maximum 8 marks)

- This section lets you show what you understand of the background scientific knowledge and understanding which will help you evaluate the information from your sources.
- You should assume that your target audience is intelligent, but doesn't know anything about the topic. You should explain the basic ideas of the topic and your student textbook or own notes will be a good source. This can be backed up by extra information from more advanced or specialist books, encyclopaedias or web-sites.
- Think carefully about whether the articles you read are based on scientific evidence or not, and explain how reliable you think these claims are.

C Quality of Conclusions: (maximum 8 marks)

- There should be evidence that the sources you used have been compared to check for consistency and to identify areas of conflict or disagreement. There should also be evidence that the underlying science has been used to try to resolve any differences.
- There should be evidence that points 'for and against' have been compared.
- You should describe your view-point or position in relation to the original question, and justify this by reference to the sources.

D Quality of Presentation: (maximum 4 marks)

- Think about who you want to look at your report – make it attractive and interesting for them.
- Give the report a good clear structure by using headings and/or sub-headings and a table of contents. This helps to break up the report and guides readers quickly to particular sections.
- Reports should also include suitable tables, diagrams and graphics to clarify difficult ideas or to present large amounts of data in a quick and easy way. Do not include graphics just to decorate your report, they must provide useful information.
- Be careful to write clearly, with correct spelling and grammar.

Case study checklist

Title page:

- Title of case study written in the form of a question

Contents page:

- Sections, sub-sections and appropriate page numbers included

Introduction:

- Explanation of what the case study is about and how the report is structured

Scientific theory:

- Relevant background science included

Evidence:

- Relevant information from sources collected with detailed references in each case
- Evidence from both sides of the case
- Authenticity and reliability of the evidence recognised; explanation of the evidence using underlying science

Conclusion:

- Evidence compared and evaluated
- Conclusion written and justified, pointing out any limitations or alternative interpretations

Bibliography:

- References listed in detail

Presentation:

- Report clearly organised into appropriately headed sections and in a suitable sequence
- Report includes diagrams, data tables, graphs etc. to illustrate ideas and concepts
- Report is concise, uses relevant scientific terminology and has correct spelling, punctuation and grammar

Appendix F: Examples of Completed Case Studies with Commentaries

Script CS-06-B01

What is cloning?

Information from (Human Genome Project Information)
When the media report on cloning they are usually talking about only 1 type of cloning called ***Reproductive Cloning***. However there are different types of cloning and cloning technologies that can be used for other purposes besides producing the genetic twin of another organism. A basic understanding of the different types of cloning is key to taking an informed stance on current public policy issues and making the best possible personal decisions. The following 3 types of cloning technologies will be discussed: (1) Recombinant DNA technology or DNA cloning, (2) Reproductive cloning, and (3) therapeutic cloning.

Is cloning a good idea

I think cloning is a good idea as it could help
Prevent diseases and if someone dies because of some
One else then they could live there lives again and
Maybe the same thing won't happen again.

Is cloning a bad idea

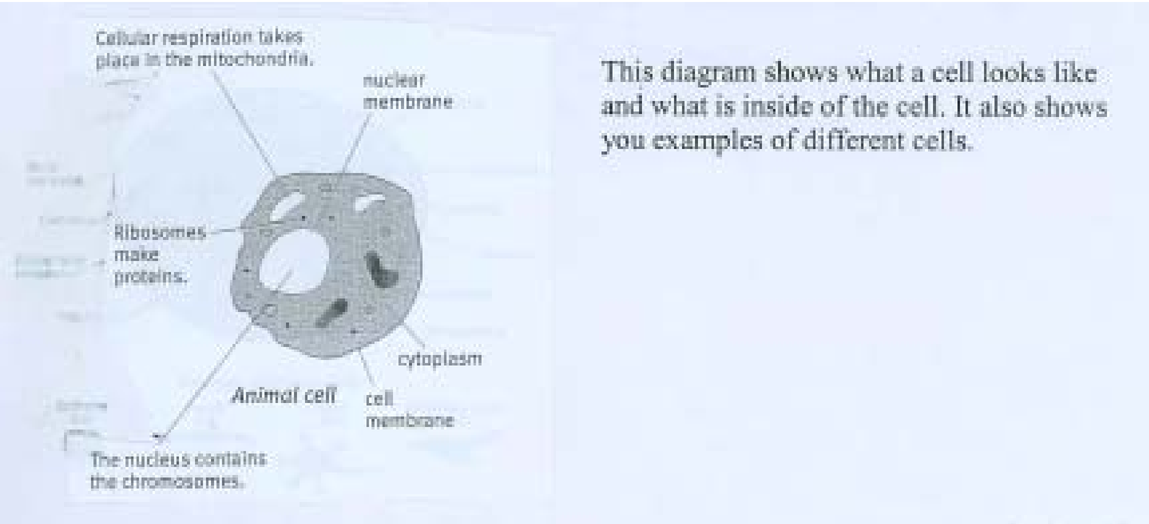
Cloning could be a bad idea as people may take
Advantage of this and just clone anything when cloning could be used to just help
people who need a new kidney or something like that.

WHY PEOPLE THING CLONING IS UN ACCEPTABLE

Dr Wilmut, the scientist involved, and his colleagues at Roslin have made it quite clear that they think that to clone humans would be unethical. The Human Fertilisation and Embryology Authority agree with the general public impression that to clone human beings would be ethically unacceptable as a matter of principle. I and most people in the Church of Scotland would certainly agree that on principle, to replicate any human technologically is something which goes against the basic dignity of the uniqueness of each human being in God's sight. Christians would see this as a violation of the uniqueness of a human life, which God has given to each of us and to no one else. In what sense do we mean this?

Some say that the existence of "identical twins" means that we should have no ethical difficulty over cloning, or that to object to cloning implies that twins are abnormal. This argument does not hold. Biologically, identical human twins are not the norm, but the unusual manner of their creation does not make them any less human. We recognise that each is a uniquely valuable individual. There are two fundamental differences between cloning and twinning, however. Twinning is a random, unpredictable element, involving the duplicating of a genetic composition which has never existed before and which at that point is unknown.
Cloning would choose the genetic composition of some existing person and make another individual with the same genes. It is an intentional, controlled action to produce a specific known end. In terms of ethics, choosing to clone from a known individual and the unpredictable creation in the womb of twins of unknown genetic nature belong to categories as different as accidental death is to murder. The mere existence of "identical" twins cannot be cited to justify the practice of cloning.

<u>What do cells look like and what's inside a cell?</u>



<u>How do scientists clone animals</u>

The scientist clone animals by taking the eggs from the animal and growing them then put them back inside the animal for them to grow correctly and be born.

<u>The famous clone Dolly the sheep</u>

Dolly the sheep became a scientific sensation when her birth was announced in 1997. Her relatively early death in February 2003 fuels the debate about the ethics of cloning research and the long-term health of clones.

The challenge

When you cut yourself, new skin grows over the wound because skin cells are 'programmed' to produce new skin. This is vital while you are healing or growing and even means we can grow some cells – such as human skin – in the laboratory.

In contrast to this, a newly fertilised egg contains 'stem; cells, which are capable of becoming any of the hundreds of different types of cell in the body – skin, muscle, brain cells etc.

The challenge faced by Dolly's creators was to take a fully programmed adult cell and return it to this state – de-program it.

Reprogramming DNA

Exactly how ‘adult’ DNA is reprogrammed is a mystery. At the Roslin Institute, scientists replaced the nucleus of the egg cell with the nucleus from the parent cell – in Dolly’s case, an udder cell. Somehow, the egg cell reprogrammed the donated DNA contained within its new nucleus, and Dolly was the result.

The manipulation was done using microscopic needles, a method pioneered in human fertility treatments in the 1970s. The resluyting embryo was implanted into the womb of a third, surrogate sheep. Dolly was born on 5 July 1996, and her birth was announced in early 1997.

The future

Little about the process that created Dolly was actually new. Technically, Dolly was not even the first clone, but she was the most famous.

Potential uses for cloning whole animals may include farming, producing proteins for medical and nutritional use, or the cloning of genetically modified pigs to be organ donors for humans. Additionally, “therapeutic” cloning which involves cloning embryos in order to collect cells could lead to treatments for many human degenerative conditions, such as Alzheimer’s and Parkinson’s diseases.

However, public opinion is divided on the ethics of any type of cloning and Dolly’s death will fan the flames on the debate.

Dolly the sheep RIP

At 15:30 on Friday February 2003, scientist at the Roslin Institute decided that Dolly, the world’s most famous sheep, should be put down. She had been suffering from a progressive lung disease.

Dolly’s death, like her birth, is bound to raise fresh fears about the wisdom of cloning.

An early death?

At only 6 years old, Dolly was relatively young when she died. But there’s no proof that cloning was to blame.

‘Sheep can live to 11 or 12 years of age, and lung infections are common in older sheep, particularly those housed indoors. There is no evidence that cloning was a factor in Dolly contracting the disease. ‘
Dr Harry Griffin, Acting Director, Roslin Institute.

Old before her time?

Because Dolly’s genetic material came from a 6-year-old sheep, questions have always been asked about her “true” age.

In 1999, some of the scientist who created Dolly studied her genetics. They found that structures in her cells called telomeres were slightly shorter than would be expected in a sheep of her age conceived naturally – so in a way Dolly’s DNA was ‘older’ than her body. Scientist realised then that Dolly might die young.

Cause of death

A post –mortem examination confirmed the cause of Dolly's lung problems as sheep pulmonary adenomatosis (SPA), a lung tumour brought on by a virus.

The examination also confirmed what vets had suspected since early 2002 – that she had arthritis in her hind legs. Until the first signs of arthritis were detected, Dolly had shown no signs of ill health and had given birth to four healthy lambs.

No other abnormalities were uncovered by the post-mortem. There's no proof that Dolly died young because she was a clone, but scientists still have many questioins about cloning.

Dolly and human cloning

Ian Wilmut, who led the team that cloned Dolly, has always spoken out against human cloning.

It took hundreds of attempts to produce Dolly and, even now, the cloning process is far from perfect. Dolly's arthritis and now relatively young death fuel concerns that even clones appearing healthy at birth may have underlying genetic abnormalities.

But after all, she's only one sheep, and the results of her post-mortem haven't given us concrete answers about the safety of cloning. The handfuls of experts who advocate human cloning are unlikely to be deterred.

Famous Films

A famous film that I have seen about cloning is Jurassic park this film is interesting because of the way they clone the dinosaurs. They clone the dinosaurs by using DNA from a frog and dinosaur bones. It is exciting at the thought of the possibility that it could happen.

Websites I used:

www.humancloning.org
www.merck.com
www.ornl.gov
www.sciencemuseum.org.uk

By Maxine Chester

Marking Commentary on Case-study CS-06-B01

Title: Cloning.

The title was not phrased in terms of a question and this prevents a clear focus for the case study.

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	sources used			✓							2
	listing of sources			✓							
	acknowledgment of quotes			✓							
B	background science					✓					4
	recognition of evidence					✓					
C	comparison of views				✓						2
	conclusions			✓							
D	structure & organisation			✓							2
	illustrations/tables/paragraphs		✓								
	QWC				✓						
	Total mark for the case study										10

Strand	**Aspect**	**Mark**	**Commentary**	**Mark**
A	a	2	A limited range of sources were used to provide information	2
	b	2	Website addresses were included in the bibliography but they were not sufficiently detailed to allow easy access	
	c	2	A good deal of information was included about 'Dolly the sheep' and the 'Roslin Institute' but direct quotations were rarely indicated	
B	a	4	There is information about 're-activating' genes, but much basic genetics is missing.	4
	b	4	The scientific evidence behind the headlines of the 'death of Dolly' was described in some detail	
C	a	3	Most of the information appears to be cut-and-pasted from websites without any clear view being expressed.	2
	b	2	There is some attempt on the first page of the report at summarising 'is cloning a good idea or not? The ethical arguments are referred to.	
D	a	2	There is some structure but little coherence in the report	2
	b	1	There is little visual material	
	c	3	There is very little in the candidate's own words to use as a basis for judgement. Scientific terminology is used appropriately.	
			TOTAL for the Case-study	10

Case study
Science

SHOULD HUMAN CLONING BE ALLOWED

CASE STUDY

COURSE WORK

Case study
Science

Introduction:

In my case study, I will be looking at weather should human cloning be allowed? The possibility of human cloning, raised when Scottish scientists at Roslin Institute created the much-celebrated sheep “Dolly” (Nature 385, 810-13, 1997), aroused worldwide interest and concern because of its scientific and ethical implications.

What is Cloning?

Human cloning is the creation of a genetically identical copy of an existing human or growing cloned tissue from that individual. The term is generally used to refer to artificial human cloning; human clones in the form of identical twins are commonplace, with their cloning occurring during the natural process of reproduction. As per biology, a clone is a cell or an organism that is genetically identical to another cell or organism. Many simple organisms such as bacteria reproduce themselves by copying their DNA and splitting in half. The two bacteria that result from this form of asexual reproduction are genetically similar; they are clones of each other. In contrast, during the process of sexual reproduction, the nucleus of a sperm cell, which carries the father’s DNA fuses with the nucleus off the egg cell, which contains the mother’s DNA. The resulting offspring carry genetic material from both parents and are not identical to either parent.

Case study
Science

<u>Are there different types of cloning?</u>

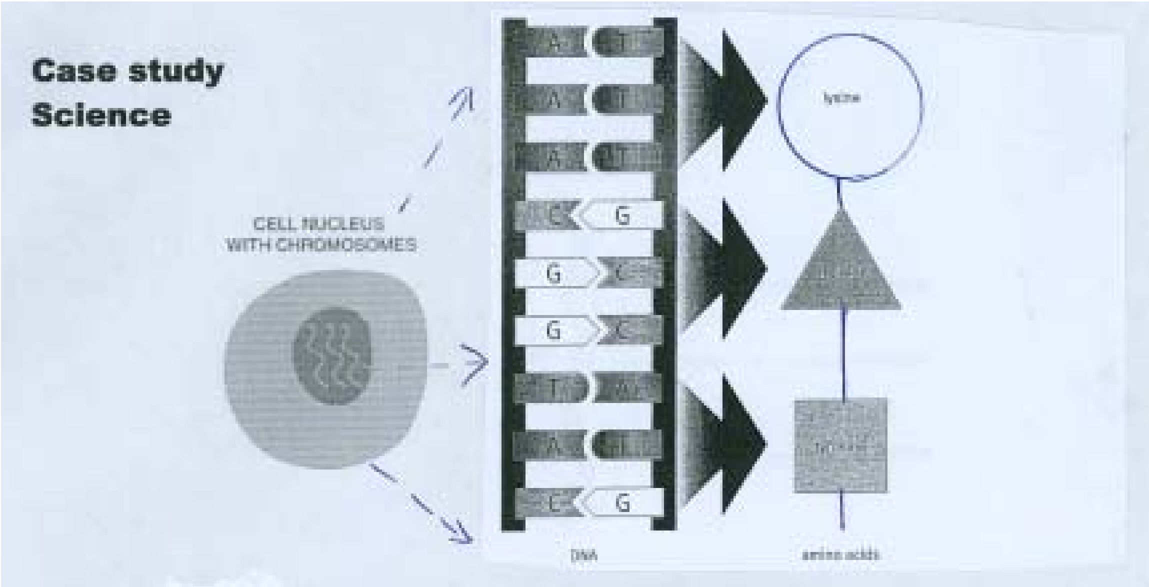
There are different types of cloning however, and cloning technologies can be used for other purposes besides producing the genetic twin of another organism. A basic understanding of the different types of cloning is key to taking an informed stance on current public policy issues and making the best possible personal decisions.

<u>Cloning of Dolly Celebrity Sheep Has Died at Age 6</u>

Dolly (A Sheep), the fist mammal to be cloned from adult DNA, was put down by lethal injection Feb. 14, 2003. Dolly had been suffering from lung cancer and crippling arthritis. Although most Finn Dorset sheep live to be 11 to 12 years of age, post mortem examination of Dolly seemed to indicate that, other than her cancer and arthritis, she appeared to be quite normal. The unnamed sheep from which Dolly was cloned had died several years prior to her creation. Dolly was a mother to 6 lambs, bred the old-fashioned way.

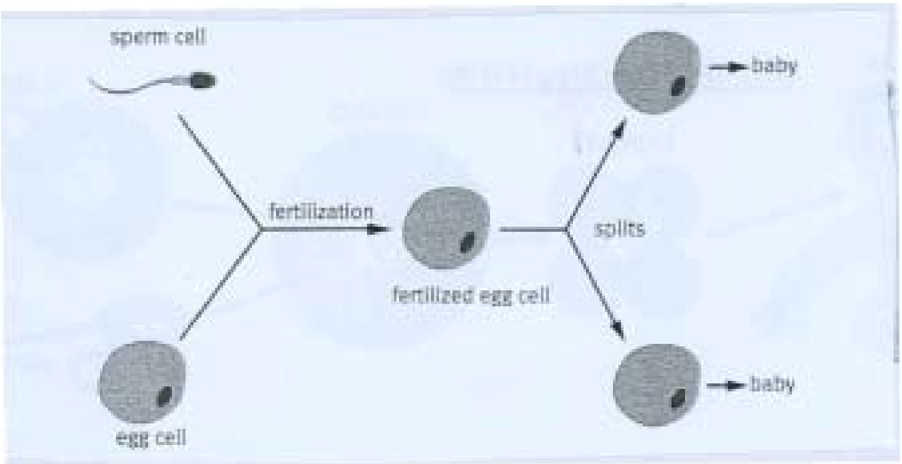
I. Genes

Genes are strings of chemicals that help create the proteins that make up you r body. Genes are found in long coiled chains called chromosomes. They are located in the nuclei of the cells in you body:

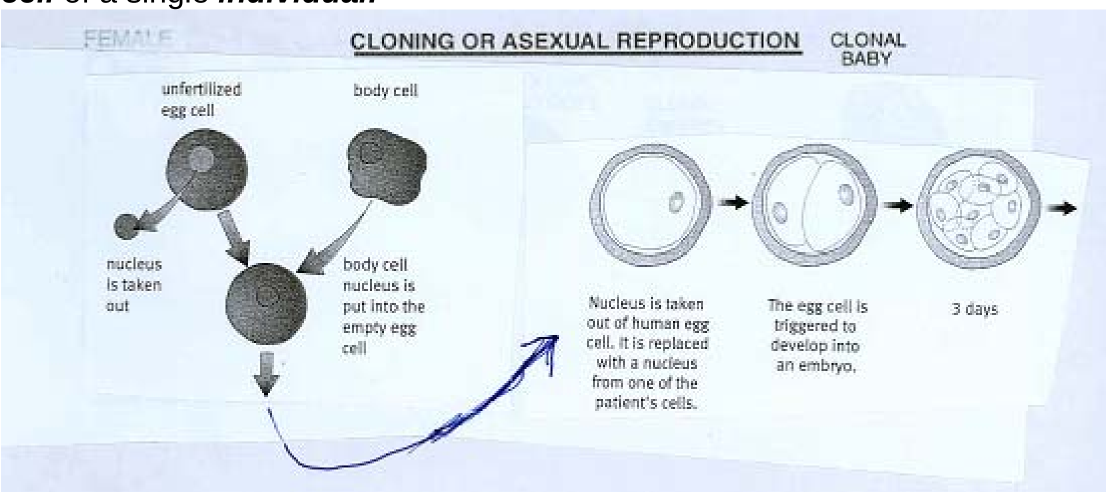


II. "   WAYS TO MAKE AN EMBRYO"

In sexual reproduction a child gets half its genes from its mother (in her egg) and half from its father (in his sperm):



Cloning is an asexual from of reproduction. All the child's genes would come from a ***body cell*** of a single ***individual:***



Case study
Science

Cloning an Animal vs Cloning a Gene

You've heard about cloning animals – sheep, mice, even house pets – in the news. From time to time, you may have also heard about researchers cloning, or identifying, genes that are responsible for various medical conditions or traits.

What is the difference?

Cloning an animal, or any other organism, refers to making an exact genetic copy of that organism.

Cloning a gene means isolating an exact copy of a single gene from the entire genome of an organism. Usually this involves copying the DNA sequence of that gene into a smaller, more accessible piece of DNA, such as a plasmid. This makes it easier to study the function of the individual gene in the laboratory.

Discussion of article 1:

I looked a NEWSCIENCE article from the internet in December 2004. This article is a 'for' article because it says that "*remove the ethical objection that some people have to harvesting from donated human embryos*." And it also says that "*stem cells which can develop into many different cell types could be used to treat a range of diseases*." because when you develop into many different cell types you wouldn't have any diseases in you body. I do agree with this article because my stem cells wouldn't be diseased after they developed into many different cells.

Discussion of article 2:

I looked at RADIOTIME article from the magazine on 18-24 march 2006. This article is a 'against' article because it says that "*does it imply that disable people living their lives today are in some way 'imperfect' or lucky to be alive*? this means that disable people lives by them selves so is this why they are alive in this time today so it is not the case that we should donate people with different other cell. I also agree with this article because whether you donate people or not at the end of the day everyone is going to die so there is no point of donating people. Article 2 does not agree with article 1.

Discussion of article 3:

I looked at GOODBYE DOLLY article from the general science booklet. This article is 'for and against' article because it says that '*killing an embryo at any age is as wrong as killing a chills or an adult*' this is an 'against' quote. It also says that '*if we are prepared to kill cows and sheep to eat, why should we worry about a group of cells with a far less advanced nervous system?*' and this is an 'for' quote. I agree with this article because it proves in both ways that donating people is either good or bad. Article 3 does agree with article 1 and 2.

Conclusion:

In my conclusion I think that human cloning shouldn't be allowed. I think this because I believe and trust article 2. I think this because I took the article from a normal daily magazine. Both points for and against are more important to me because I would want to know weather if donating people has a good side and a bad side to it so therefore I prefer to look at both things so that nothing would happen to no one if three is an side affect to it. In my own view I wouldn't like to be cloned because I wouldn't want no one else taking over my place even though it looks like doesn't mean its me we would both have something different. This is all I've got to say about my conclusion.

Bibliography:

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http://news.bbc.co.uk/1/hi/talking_point/1923149.stm

Marking Commentary on case study CS-06-B02

Title: Should human cloning be allowed?

It is very useful to have the title written in terms of a question which provides an immediate focus for the Case Study.

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	sources used				✓						3
	listing of sources					✓					
	acknowledgment of quotes				✓						
B	background science						✓				5
	recognition of evidence					✓					
C	comparison of views					✓					4
	conclusions					✓					
D	structure & organisation				✓						3
	illustrations/tables/paragraphs				✓						
	QWC			✓							
	Total mark for the case study										15

Strand	Aspect	Mark	Commentary	Mark
A	a	3	Stimulus material appears to have been provided by the centre but the candidate has gathered further material from other sources as indicated in the bibliography. There is no reference to the confidence level that can be attached to the sources.	3
	b	4	References are clear and detailed.	
	c	3	References are clear but not from the other sources.	
B	a	5	The relevant background science is described in the early stages of the report but further detail is needed to raise the achievement level and make a secure match to the higher mark descriptions	5
	b	4	The information quoted from the stimulus material is linked to the underlying science albeit briefly	
C	a	4	Information from different viewpoints is identified vas ‘for’ or ‘against’ but not directly compared of evaluated.	4
	b	4	A simple limited conclusion is made but the justification is weak and not clearly linked to the evidence given.	

Strand	Aspect	Mark	Commentary	Mark
D	a	3	The report has an appropriate structure with suitable sub-headings. There is no contents page but pages are numbered and there is a bibliography	3
	b	3	Schematic diagrams are used to convey information effectively. The original included two photographs for which copyright could not be obtained and these just tipped the balance between 2 and 3	
	c	2	Spelling is generally sound. In places, e.g. discussion of article 2, the grammar becomes very confused. There is also misuse of technical term e.g. ‘donating’ instead of ’cloning’	
TOTAL for the Case Study				15

Cloning.

Black = my own writing
Italics = the information that I have found from different resources

Cloning

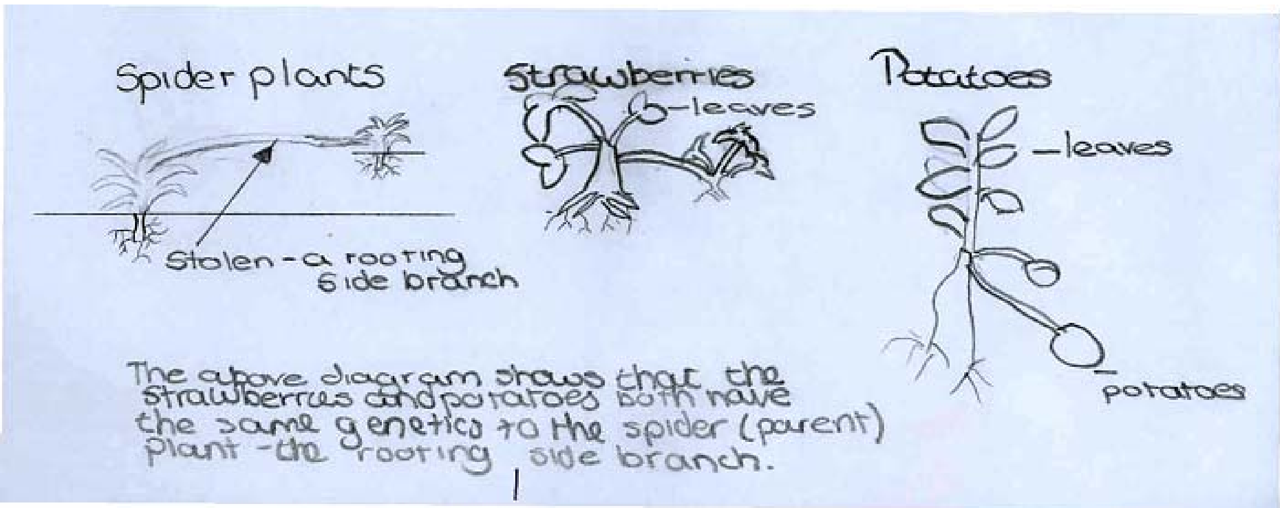
I am going to look at the 'for' and 'against' argument for cloning. I will explain all the different types of cloning and I will be looking at scientist's evidence and evaluating whether or not it's reliable. I will also include my point of view on all points made. I am doing this to put across the positive and negative aspects of cloning.

What is a clone?
Clones are genetically identical living organisms and can be produced commercially by taking cuttings. All the clones of 1 plant have the same genes and the same genetic history so therefore they have the same characteristics.

This enables huge numbers of identical plans to be produced, but they will all be susceptible in variation. Reference found in OCR science book – Lonsdale revision guide.

There are many different types of cloning such as, asexual cloning, commercial cloning of plants, animal cloning, and human reproduction.

Cloning techniques in plants.
Plants can reproduce asexually. Asexual reproduction is when some living things only need one parent to be reproduced. This is done when single celled organisms called Bacterium grow and then divided into two or even three cells. All the offspring produced asexually are clones I.E. they are genetically identical to the parent plant.



Larger plants and animals that are cloned have different cells for different jobs that go on in the body and help it work. Embryo cells are able to change into any cell in the body such as red or white blood cells, a nerve cell or a muscle cell for any part of the body. This is how a baby develops over time.

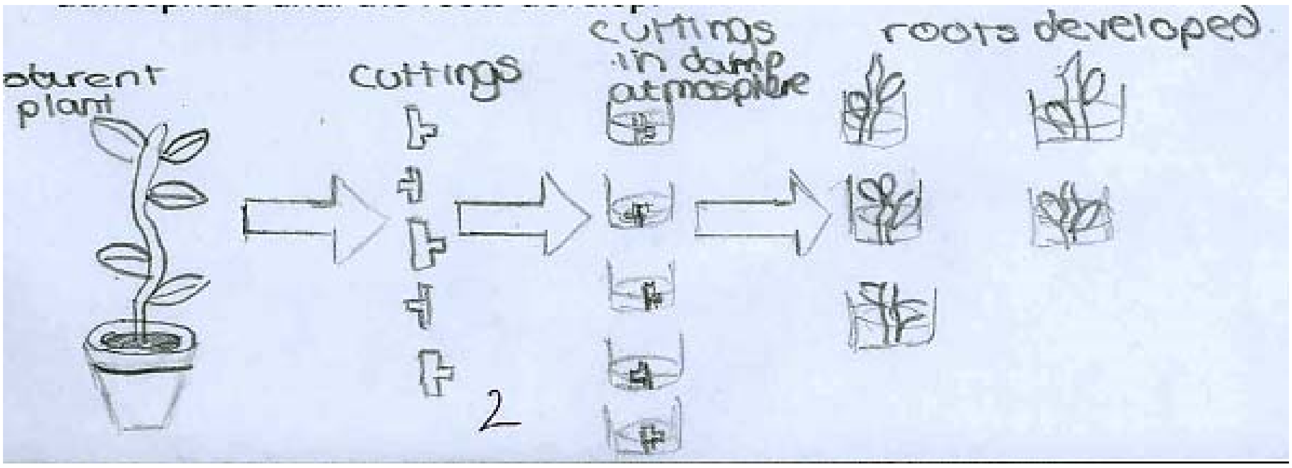
Commercial cloning of plants

Clones are genetically identical to the parent plant so if a plant breeder creates a brand new type of plant he will clone millions of them to make money. For example a farmer can clone a certain crop to sell and make money.
Therefore he will have to clone lots of them and place them all in the same environment while they grow. This is an effective way to clone but it has disadvantages as well as advantages.

Advantages	Disadvantages
You can be sure of the characteristics of the plants since they will all be the same to one another.	If the plants become easily affective to disease or sensitive to a change in the environment then all the plants will be affected and change.
It is possible to produce huge numbers of plants which may be more difficult and slower to grow from seed.	The reduction in genetic variation reduces the potential for further selective breeding.

How to clone a plant from cuttings

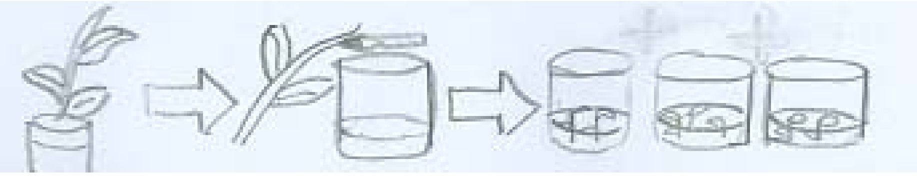
Any gardener can do this as its quite simple. The gardener can do this by taking cuttings from the stem, leaf or the root. They should be grown in the best conditions for example in a damp atmosphere until the roots develop.



Step by step instructions to the above experiment.

1. *Fill a small pot with compost.*
2. *Cut the stem about 10cm from the tip just below an leaf, using a sloping cut (I.e. cut at an angle, not straight across).*
3. *Take off the lower leaves and other leaf-like bits.*
4. *Dip the cut end of the stem in rooting powder if you have any.*
5. *Gently push the cutting onto the compost until the compost is just below the lowest leaf.*
6. *Label your pot with your name and the date. Put a plastic bag loosely over the plant.*
7. *In a few weeks time your plants will have grown roots. AC2.11B cloning plants.*

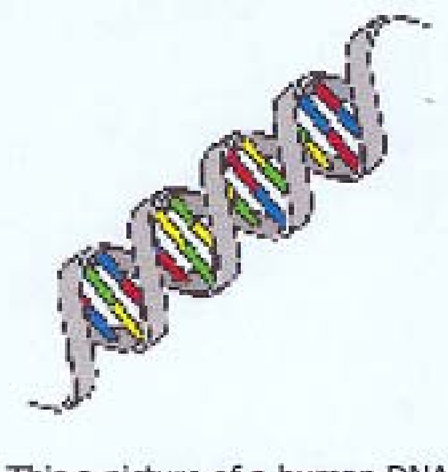
Tissue culture.
This method involves a few cells being taken from the parent plant into a beaker with nutrients and hormones with in it. Leave it for a few weeks and lots of genetically identical plantlets growing. The process can be carried out again.



Some people will think that asexual cloning is a bad thing as it means that something as been produced to make it identical to something else so therefore it won't have its own beauty. People for cloning plants asexually will think that it is a natural thing to do because it can help somebody make money if they clone millions of a healthy plant. It also means that they can have they same plant and its characteristics all the time just by using the simple cloning method of taking cuttings. A religious view on cloning will be that it isn't right because if it means recreating something that God had created, which to them would seem wrong. I believe that cloning plants is ok as if you have a plant that grows perfectly in your environment then you will clone it to have that plant year after year.

Human cloning can be done but it will take 1000's of attempts and it will have a great cost. There could even be a chance that some people may lose there lives if it goes wrong.

Cloning humans is extremely unsafe because attempting to do so will result in miscarriages of the genetic twin for all the times that it didn't work. Success could be reached but there will have to be a lot more scientific knowledge on cloning and the way the human body produces when it is being cloned.



This a picture of a human DNA

Human genetics are much more complex than animal genetics so if you look at how many attempts to clone dolly to how many times it could take to clone a human being. This would also lead to it costing loads of money and could take a very long time.

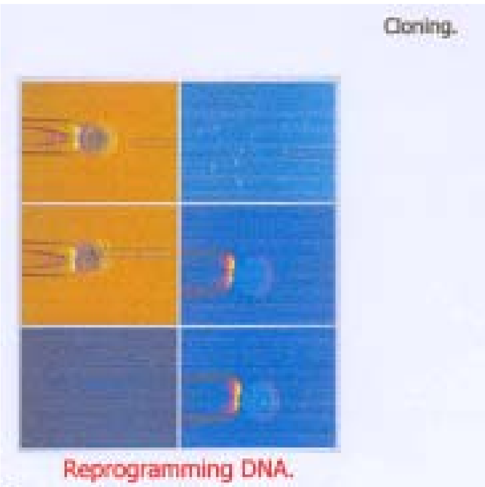
Although human reproduction is sexual, clones are sometimes produced from an early embryo, before the cells become specialised. The identical twins that are born are therefore clones of each other, but not of either of their parents. I found this information in the twenty first century, modules 1-3, core science book.

Not everything that is scientific is fact because there can be scientific ideas that are fiction and have not been able to be carried out. This can be because it has never been able to be done or we don't have the sufficient technology or simply because it is far too dangerous. *Ideas often appear in fiction before they actually happen. Science fiction* *writers may look at science knowledge and theory and think about where the ideas might lead. Sometimes the things that they predict actually happen. Until recently the idea of cloning of humans was science fiction rather than fact. The idea has appeared in books, science fiction magazines, television series, and films. I found this information in twenty first century science, modules 1-3, core.*

For	Against
Can recreate people who have passed away	Can cause woman to have miscarriages.
Cloning humans will provide a never ending supply of healthy organs.	Many people could become ill or die, through the steps that need to be taken when cloning a human.
Could always produce healthy babies that don't have brain damage.	God made everyone unique and different and that is how it should stay.
Couples that can't have children will be able to have one through human cloning.	If a person has passed away and then they are recreated but die early then it could make people grieve again for that person/animal.
	Cloning can damage the embryo.

<u>Dolly the sheep.</u>
Dolly was the first ever cloned sheep, and is still famous today. Dolly was born in 1996 and dies on the 14th Feb. 2003. Even though she was born in 1996 her birth was announced in 1997. Since Dolly's genetic information came from a six year old sheep then questions have been asked about her true age. This means that she might not have died young but at the average age of 11 or 12. Most people think she died early because she was a clone which also makes people see the bad side of cloning as well as the good side. Dolly was created by Ian Wilmut and his team at the Roslin Institute in Edinburgh.

The challenged that faced Ian Wilmut was to take a fully grown adult cell and return it to the same state. *Exactly how 'adult' DNA is reprogrammed is a mystery. At the Roslin Institute, scientists replaced the nucleus of the egg cell with the nucleus from the parent cell – in Dolly's case, an udder cell. Somehow, the egg cell reprogrammed the donated DNA contained within its new nucleus, and Dolly was the result.*



Information found at http://www.sciencemuseum.org.uk/antenna/dolly/index/asp
It took hundreds of attempts to lone Dolly which show that people still don't know exactly how to do it. It has also cost a great amount of money to produce Dolly but many say that it was money well spent.

Many people think that cloning should be stopped and others think that it should carry on because if god give us the power why shouldn't we use it?

How cloning is being passed to us using movies.

Cloning is being showed to us using movies. This is to try and make people see the good in cloning more than the bad. A good example is Jurassic park, when they are cloning the dinosaurs.

A scientist of today could clone a dinosaur but he would have to have a mosquito that has sucked the blood from a dinosaur and then has been fossilized in amber. There is no oxygen in the amber fossil to cause the mosquitoes stomach to decay, a scientist would then remove the nucleus from the eggs of a reptile and replace them with the DNA of a dinosaur that were found in the mosquito. After looking after the dinosaur egg in the right way then the original dinosaur will be hatched.

Other movies that show cloning are;

The Lost World – Dinosaurs are cloned again and so are the special effects!
The Boys from Brazil – A cult classic involving the Hitler scenario starring Gregory Peck and Laurence Olivier.
Sleeper – a Woody Allen movie.
Multiplicity – Michael Keaton is cloned, Andie MacDowell
Invasion of the Body Snatchers – Pods are clones in this science fiction classic.
A Stolen Life – With Bette Davis and Glenn Ford, actually a movie about twins, but twins are clones.
Clones – A 1973 movie.
The Clones of Bruce Lee – 1984 martial arts movie.
Blade Runner – A science fiction classic.
Star Wars – Clones and clone wars.
Judge Dredd
American Ninja 2
Twins – Danny DeVito and Arnold Schwarzenegger are twins (clones).
Gattaca – Stars Ethan Hawke and Uma Thurman in a futuristic look at genetic engineering.
Alien Resurrection – A great sequel in which Ripley (Sigourney Weaver) is cloned to once again fight the aliens. I found this information at http://www.humancloning.org/movies.htm

All these movies represent cloning in a positive way to change people's minds to think that cloning is good.

Unsuccessful clones

There have been many unsuccessful clones over time. An unsuccessful clone is when you take out the nucleus and change the DNA but something goes wrong and nothing is produced.

It took 277 attempts to successfully clone Dolly the sheep so all the over attempts must have been unsuccessful but since at the end of all the work there was a successful clone then everybody forgot the unsuccessful attempts.

Environment.

The environment plays a big part on a clone because it can determine on how long a clone lives and how healthy it is. Such as if two of the same plant has been cloned and they are both placed in different environments then one could die earlier because one could be in a countryside with fresh air and lots of sun and the other could be placed in the city with polluted air and very little sun. The environment can affect the characteristics and the way it grows. The cloned plant is genetically identical to the plant it has been cloned from; therefore it means they will both have to be in the same environment to survive.

Religious views.

For	Against
It is not in the bible that we can not do it, so there is nothing wrong with it.	Some people think that our human life is a gift from god and therefore that gift should never be copied or taken for granted.

The Roman Catholic Church is against cloning. *The official opinion of the Roman Catholic Church is that " every possible act of cloning humans is intrinsically evil" and could never be justified (NBAC 54). Their religious and ethical tradition informs this viewpoint which is largely based on their interpretation of the creation story. From the story of creation Roman Catholics infer an ethic of stewardship which dictates that humans are responsible for maintaining and preserving what nature has created I found this information on the website http://www.cs.virginia.edu/~jones/tmp352/prjects98/group1/ethic.html#r* Roman Catholics believe that men have dignity because they were made by god. Cloning violates this because some people will be identical instead of being uniquely created by God. The Roman Catholic Church is concerned that having cloning technology could tempt humans to violate the holiness of life. If clones are seen as less than equal, people might sacrifice them for the benefit of their creators, such as to provide organs for transplant. This means that all Roman Catholics should be against cloning. *The Jewish religion takes the position that "cloning humans could conceivably be justified in some circumstances, however few they may be" (NBAC54). This view is largely based on historical tradition and sacred writings, which largely focus on human destiny. The Jewish tradition emphasizes that man is in a partnership with God. Some Jewish thinkers find justification for this view in the story of Genesis which says that Adam and Eve were "to work it [the garden] and to preserve it" (Genesis 2:15). Man is obligated to care for what He has created and to improve upon creation in order to meet human needs. I have found this information on the website http://www.cs.virginia.edu/~jones/tmp352/projects98/group1/ethic.html#r* The protestant argument is against cloning are similar to the Jewish and the Roman Catholic arguments. Since there is no teaching about cloning in the Protestant Church to interpret scripture, protestant church goers look directly to the texts themselves for guidance. While the Bible does not exactly say anything human cloning, its teachings about marriage, parenthood, and childhood relate to this technology, and it shows that children should be created by two parents so the baby has two sets of genes. *Islamic attitudes regarding human cloning stem from deeply held Muslim beliefs and interpretations of the Koran. This holy book governs every aspect of Muslim life and is believed to contain the word of Allah (the Arabic word for God). Islamic thinkers disagree over which traditions to emphasize when they come in conflict. I found this information on the website http://www.cs.virginia.edu/~jones/tmp352/projects98/group1/ethic.html#r.* Not all the Muslim thinkers are against cloning. They argue that there should be no limits on any kind of research because God gave us the power and let us create the equipment to be able to be able to do this so it is allowed by God. There are many different religious opinions but they are all believed in by different religion believers.

Conclusion

In conclusion there are many different arguments for cloning. Each argument can be backed up with evidence that explains the point being made such as; if cloning can be done then why not do it? This point can be backed up because it doesn't say that cloning is not allowed in the bible so it can't be against Gods wishes. But some people argue this point by saying that God creates us all separately and uniquely so that we are all different so if we start to clone then we aren't following God. The question that most people find themselves asking is: Human cloning, should it be allowed? There is to sides to this questions and both sides can be believed. For example; human cloning is allowed in other countries and some think that it should be allowed in the UK as well because we have the technology to make it happen. Others think that it is wrong because everyone is different to one another as this is how God made us and if we clone a human being then not everyone will be different, which is against Gods ways.

Religious arguments are based largely on the traditions and scriptures unique to each faith. Different religions have different attitudes towards cloning and within each faith there is diversity of opinion. Information found at http://www.cs.virginia.edu/~jones/tmp352/projects98/group1/ethic/html#r. An example of a religious view on cloning is, In Judaism religion children need both a mother and a father and when a clone is produced it could mean that a man could become a father without a mam becoming a mother at the same time.

My views on cloning are that it is wrong and should not be done. This is because it is like taking some ones life and giving it to some body else. I think that the cloning of plants is fine as it is an easy method and can be done at home. Cloning should be banned and people should be made by sexual intercourse.

Marking Commentary on case study CS-06-B03

Title: Cloning

The colour version of this script includes text highlighted in 'red' to identify information from sources (this might affect decisions based on the black & white version).

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	sources used				✓						4
	listing of sources					✓					
	acknowledgment of quotes					✓					
B	background science						✓				5
	recognition of evidence					✓					
C	comparison of views							✓			5
	conclusions					✓					
D	structure & organisation				✓						3
	illustrations/tables/paragraphs				✓						
	QWC				✓						
	Total mark for the case study										17

Strand	Aspect	Mark	Commentary	Mark
A	a	3	A variety of information is selected from websites and the 21C Science texts but there are no references regarding the reliability of the sources.	4
	b	4	Although there is no collected listing of sources, they are acknowledged and most references are fully detailed.	
	c	4	Quoted information from sources is indicated in 'red' throughout the report	
B	a	5	Information is given about asexual reproduction in plants, but there is a lack of detail about cloning of animals or humans.	5
	b	4	Parts of the science involved in the cloning of 'Dolly the sheep' is illustrated and also the cloning in plants. There is reference to the basis of views amongst religious groups.	
C	a	6	The study presents both scientific evidence of what is possible and some of the problems in putting it into practice, and also a comparison of religious views. There is also an interesting survey of how cloning is presented in films. However information tends to be simply presented without comment or evaluation.	5

Strand	Aspect	Mark	Commentary	Mark
	b	4	The page header 'conclusion' presents a summary of views from different groups, but the candidate's own conclusion is brief and rather simplistic and does not relate back to the evidence sufficiently.	
D	a	3	The report has a contents list and uses sub-heading to provide structure, but tends to jump from one aspect to another without a clear progression.	3
	b	3	Some visual material is informative and the highlighting of text is helpful as regards presentation.	
	c	3	Spelling, punctuation and grammar are generally sound and there is reasonable use of scientific terminology.	
TOTAL for the Case-study				17

Appendix G: Marking Criteria for Investigation (A230)

Within each strand, different aspects of performance are identified. Achievement related to each of these is assessed, and the professional judgement of the teacher is then used to award an overall mark out of 8 for the strand.

Strand S: Strategy

Practical investigations are likely to arise out of work on most or all of the course modules. Suitable tasks might be suggested to candidates, but they should also have opportunities to modify or extend these, or to suggest questions or tasks to investigate in topic areas they are studying. Candidates can (and should) obtain more credit for tackling somewhat more demanding tasks, and for being involved in devising the question/task, rather than 'playing safe' with a given, or routine task, or one involving little skill in the use of equipment.

Whilst candidates should be encouraged to plan an investigation before starting, there is limited value in requiring them to produce a detailed written plan – as their actions should be open to modification as they proceed. Indeed, it is good practice to try taking a few measurements or making a few observations to get a 'feel' for the equipment and the system being investigated, before planning a detailed data collection strategy. For that reason, the candidate's understanding of issues concerning data is better assessed from the final data set they present (see strand C below), rather than from an initial plan.

Assessment of the quality of strand S focuses on:

- the complexity and demand of the task and approach chosen;
- the choice of equipment, materials and techniques;
- the degree of independence shown in formulating the task and the approach to it.

Aspect of Performance	Strand S Mark			
	2	4	6	8
a complexity and demand of task	Simple measurement or comparison task, based on straight-forward use of simple equipment.	Routine task requiring only limited precision or range of data to be collected.	Straightforward task of limited complexity, but requiring good precision or a wide range of data.	Complex task requiring high levels of precision/reliability in the data collected.
b techniques used	Follow a given technique, but with very limited precision or reliability.	Select and use basic equipment to collect a limited amount of data.	Select and use techniques and equipment which are appropriate for the range of data required.	Justify the choice of equipment and technique to achieve data which is precise and reliable.
c autonomy and independence	The task has been set by the teacher and/or is based on specific, task-related structured worksheets.	The task is closely defined by the teacher, but is carried out with little further guidance.	The task is defined by the candidate from a more general brief, then carried out independently.	The topic is reviewed by the candidate to justify a choice of task. The work is completed independently.

Strand C: Collecting Data

Candidates are expected to be able to collect a set of data in a manner which shows understanding of how to ensure (and assess) quality.

The quality of a data set depends on:

- the quality of individual data points, which in turn depends on:
    - o how carefully the measurements have been taken, and how accurate the available instruments are (IaS 1.1-2);
    - o how much variation or scatter there is in repeated measurements and the steps that have been taken to assess and deal with this (IaS 1.1-4);
    - o whether the instruments used, or the way they are used, results in measurements that differ from the 'true' value of the quantity (IaS 1.1-2).
- the extent and design of the set of data points collected, that is:
    - o whether enough data points have been collected (IaS 2.1, 2.3, 2.7);
    - o whether these cover an adequate range (of cases, or situations, or values of an independent variable) (IaS 2.3);
    - o (if a relationship is being explored) whether the design of the data set enables the effect of other variables to be excluded (e.g. (IaS 2.2-3, 2.6-7).

Candidates should use preliminary experiments or other information to confirm that their choices of techniques and range of values to be tested will lead to results of good quality.

The statements are written to refer to primary data that the candidate has collected. Where this is supported by data from secondary sources, the statements should be read as referring to the data 'selected' (as opposed to 'collected'). The mark awarded should be based on all of the data considered as a whole.

Aspect of Performance	Strand C Mark			
	2	4	6	8
a identification and control of interfering factors	Little or no care has been taken to identify or control outside influences.	Identifies some factors which may affect the outcomes and need to be controlled or accounted for.	Identifies the majority of factors which may affect the outcomes and need to be controlled or accounted for.	Reviews factors which might affect the outcomes and describes how they have been controlled or accounted for.
b extent and design of data set	The data is very limited in amount (e.g. isolated individual data points, with no clear pattern), covering only part of the range of relevant cases/ situations, with no checking for reliability.	An adequate amount or range of data is collected, but with little or no checking for reliability.	Data is collected to cover the range of relevant cases/ situations, with regular repeats or checks for reliability.	Values tested are well-chosen across the range, with regular repeats and appropriate handling of any anomalous results. Preliminary tests are used to establish the range.
c quality/ precision of manipulation	Little care evident in use of apparatus. Data generally of low quality.	Use of techniques and apparatus generally satisfactory. Data of variable quality, with some operator error apparent.	Sound techniques in use of apparatus/ equipment. Data of generally good quality.	Consistent precision and skill shown in use of apparatus/ equipment. Where appropriate, checks or preliminary work are included to confirm or adapt the apparatus or techniques to ensure data of high quality.

Strand I: Interpreting Data

Candidates are expected to be able to:

- present or process a set of data in such a manner as to bring out any 'patterns'[1] that are present;
- state conclusions based on these patterns;
- relate their conclusions to scientific theories or understanding;

In the following table, each row represents increasing achievement in a different aspect of performance.

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data-sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations e.g. correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion	Use complex processing to reveal patterns in the data e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.
b summary of evidence	Note differences between situations/cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or 'common sense'.	Relate the conclusion to scientific ideas/explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

[1] 'Patterns' here means similarities, or differences, or the presence or absence of a relationship (e.g. a correlation between a factor and an outcome, or a trend linking two variables).

Strand E: Evaluation

Candidates are expected to be able to look back at the investigation they have carried out, showing what they have learned from doing it and explaining how they would modify it in the light of this, were they to carry it out again. These suggestions may demonstrate understanding of:

- difficulties in collecting valid and reliable data;
- weaknesses in the design of the data set collected, such as imperfect control of other variables, or the size and matching of samples compared;
- assessing the level of confidence that can be placed in these conclusions.

Aspect of Performance	Strand E Mark 2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and about safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment, used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree of scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any anomalies.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusions more secure.

Strand P: Presentation

The ability to report clearly and effectively on one's work is essential in order to demonstrate understanding of the Ideas about Science that relate to practical investigations.

Credit is awarded for three aspects of reporting and communicating a practical investigation:

- completeness of the report, with all practical procedures clearly described, all parameters and evidence reported, a full analysis of the evidence, and an evaluation of both procedures and evidence;
- presentation of the report, including layout and effective sequencing, use of illustrations as appropriate and use of graphs and charts to present information;
- correct use of English, including accurate grammar, punctuation and appropriate use of scientific terms.

Aspect of Performance	Strand P Mark			
	2	4	6	8
a description of work planned and carried out	The purpose/ context of the investigation is not made clear. Key features of experi-mental procedures are omitted or unclear.	The purpose of the work is stated. Main features of the work are described, but there is a lack of detail.	There is a clear statement of the question/task and its scope. Practical procedures are clearly described.	All aspects of the task are reviewed. Practical procedures are discussed critically and in detail.
b recording of data	Major experimental parameters are not recorded. Some data may be missing.	Most relevant data is recorded, but where repeats have been used, average values rather than raw data may be recorded.	All raw data, including repeat values, are recorded.	All relevant parameters and raw data including repeat values are recorded to an appropriate degree of accuracy.
	Labelling of tables is inadequate. Most units are absent or incorrect.	Labelling is unclear or incomplete. Some units may be absent or incorrect.	All quantities are identified, but some units may be omitted.	A substantial body of information is correctly recorded to an appropriate level of accuracy in well-organised ways.
	Observations are incomplete or sketchily recorded.	Recording of observations is adequate but lacks detail.	Observations are adequate and clearly recorded.	Observations are thorough and recorded in full detail.
c general quality of communication	Spelling, punctuation and grammar are of generally poor quality. Little or no relevant technical or scientific vocabulary is used.	Use of appropriate vocabulary is limited. Spelling, punctuation and grammar are of very variable quality.	Appropriate scientific vocabulary is used. Spelling, punctuation and grammar are generally sound.	There is full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

Appendix H Activities Which Might be Used for Teaching or Assessment of Investigations

The biology specification provides opportunities for investigative work in every module of the course. Some of these activities can be used to introduce and develop procedural understanding of how to carry out investigations.

The suggestions given here indicate some activities related to the specification content which could be used either for developing understanding or for assessment. In a few cases some brief notes have been added in italics. These offer suggestions as to how the activity might be used and/or particular aspects of investigative work which could be brought out.

A useful early stage in planning investigative skills development and assessment would be to work up similar notes to a good range of the activities as a preliminary screening stage in selecting which ones may be of most value with particular teaching groups.

Candidates who are entered for Unit A229 could use the marks from Strands I and E of the investigation to provide the marks for the Data Analysis assessment.

B2 Keeping healthy
Investigate the effect of varying conditions on growth of bacterial cultures
B3 Life on Earth
Investigate the distribution of species in one or more habitats, e.g. to build up a picture of the interactions between different species, or investigating the effect of environmental factors on the distribution (fieldwork)
B4 Homeostasis
Investigate respiration rate of yeast/germinating peas/maggots
Investigate osmosis in potato chips in varying concentration of salt solution
Investigate the effect of temperature on protease digestion of photographic film gelatin
Investigate the effect of temperature on rennin milk coagulation
Effect of temperature on the decomposition of hydrogen peroxide using an enzyme
Investigate the cooling effect of ethanol
Comparison of body temperature at extremities and core under different conditions
Effect of body size on heat loss
e.g. this is a readily accessible task for lower achieving students but tends to attract low level responses, with inadequate ranges of data and little control of conditions.
B5 Growth and Development
Germination
e.g. broad bean seeds measuring length of root and shoot. Cress seeds grown on an inert support, irrigated with ethanoic acid/sodium ethanoate buffer solutions of different pH. Germination rates counted and data pooled for statistical analysis to link germination with pH. Better for teaching about quality of evidence than for assessment as individuals rarely have time to collect sufficient data.
Investigating auxin distribution and phototropism in shoots

B6 Brain and Mind

- Estimating the speed of a nerve impulse from reaction time experiments
- Testing areas of the tongue with bitter, sour, sweet and salt
- Photo-taxis in brine and shrimps
- Choice chambers for wood-lice

What is the concentration of solution inside the potato?

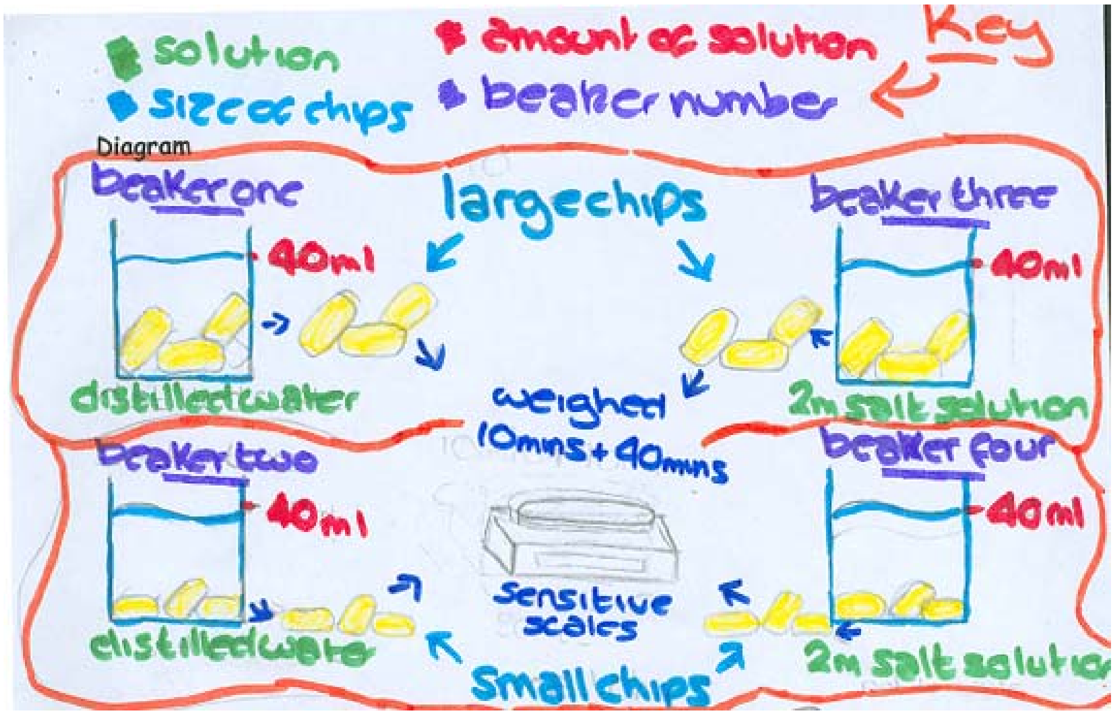
Osmosis

Preliminary

Before conducting the main investigation I had to first carry out a preliminary investigation which would give me a better understanding of the whole experiment I was about to do. I could compare better size chips, the best amount of time to leave my chips soaking for and it would give me basic information and experience I could use in my main investigation. But firstly I had to do an experiment in which would test the different effects of osmosis in different solutions. To start with I had to gather all the things I would be needing in my experiment, including

- 2 different sizes of circular cork-borers
- Measuring cylinder
- 4 beakers
- 1 scalpel
- Salt solution (2m)
- Distilled water
- Heat mat
- Clock
- 2 Potato's
- Sensitive scales

The cork borer allowed me to obtain equal width of potato, and I bored as many cylinder pieces as possible, and used the scalpel in order to ensure they were as equal as possible. 2 separate piles were created, one for the smaller chips and one for the larger chips. Then I measured the mass of all the chips ensuring I didn't forget which one was which. I then decided to choose the best chips, which would be the 6 chips of the larger cork borer which had similar mass, and then the 6 chips of the smaller cork borer which had similar mass. In this preliminary experiment we only attempted the 0 molar and 2 molar solutions; this meant we had 2 beakers with 40ml of distilled water, and 2 beakers with 40ml of salt solution.



Beakers 1 and 2 where both filled with distilled water. We decided to leave 3 large chips in beaker 1 and the 3 small chips in beaker 2 for 10 minutes, and then remove them to weigh them, and then put them back in and leave them for a further 40minutes. Whereas beaker 3 contained the other 3 large chips, and beaker 4 contained the other 3 small chips. These were both filled with 2 molar salt solution, however they were also removed at 10 minutes to be weighed, and then left for a further 40 minutes. This would determine the better amount of time for the osmosis to take place, and the better sized potato. The best amount of time will show results with a pattern, the best size will be the ones with the greater amount of osmosis taking place.
At the 10 minute weigh in I gently rolled the potato pieces on tissue paper removing any excess water/solution, and then I did the same when the whole 50 minutes were up making sure I didn't mix the chips up.

Preliminary results

Large cork borer

Distilled water

	Test 1	Test2	Test 3
before	6.29	6.26	6.32
After 10 minutes	6.32	6.27	6.33
After 50 minutes	6.50	6.51	6.61

After 10 minutes

Test 1

Percentage mass difference +0.48%

Test 2

Percentage mass difference +0.16%

Test 3

Percentage mass difference +0.16%

Average percentage mass difference +0.26

After 50 minutes

Test 1

Percentage mass difference +3.34

Test 2

Percentage mass difference +3.99

Test 3

Percentage mass difference +4.59

Average percentage mass difference +3.97

Small cork borer

Distilled water

	Test 1	Test2	Test 3
before	1.29	1.31	1.25
After 10 minutes	1.29	1.30	1.30
After 50 minutes	1.33	1.34	1.33

After 10 minutes

Test 1

Percentage mass difference -0.00%

Test 2

Percentage mass difference -0.76%

Test 3

Percentage mass difference +4.00%

Average percentage mass difference +1.08%

After 50 minutes

Test 1

Percentage mass difference +3.10%

Test 2

Percentage mass difference +2.29%

Test 3

Percentage mass difference +6.40%

Average percentage mass difference +3.93

Large cork borer

2 molar Salt solution

	Test 1	Test2	Test 3
before	5.79	6.24	6.17
After 10 minutes	5.06	5.43	5.37
After 50 minutes	4.52	4.79	4.75

After 10 minutes

Test 1

Percentage mass difference -12.61

Test 2

Percentage mass difference -12.98

Test 3

Percentage mass difference -12.97

Average percentage mass difference -12.85

After 50 minutes

Test 1

Percentage mass difference -21.93

Test 2

Percentage mass difference -23.24

Test 3

Percentage mass difference -23.01

Average percentage mass difference -22.73

Small cork borer

Distilled water

	Test 1	Test2	Test 3
before	1.29	1.31	1.25
After 10 minutes	1.29	1.30	1.30
After 50 minutes	1.33	1.34	1.33

After 10 minutes

Test 1

Percentage mass difference -19.85

Test 2

Percentage mass difference -20.61

Test 3

Percentage mass difference -22.76%

Average percentage mass difference -20.65

After 50 minutes

Test 1

Percentage mass difference -29.77

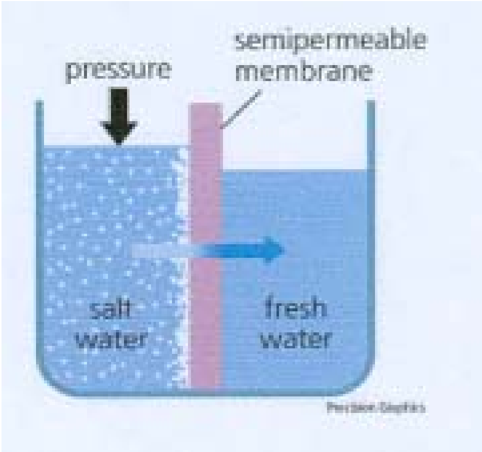
Test 2

Percentage mass difference -39.93%

Test 3

Percentage mass difference -26.83

Average percentage mass difference -31.84



This weight difference has proven to me that osmosis has had different effects with the two different liquids. The potato in the distilled water has been proven to gain weight due to osmosis, whereas the potato in the salt solution has been proven to lose weight. With the small chips the results vary a lot giving unreliable results, whereas the large chips show closely related results throughout the whole test. Such as the results for the 50 minutes salt solution; the small chips varied 12.1 grams whereas the large chips only varied 1.31 grams. The large chips definitely seem more reliable throughout the whole experiment, making them seem the better choice.
The time is another important point which needed to be investigated. At 10 minutes I could see a change in weight of the chips, however when the same chips had been left in for a further 40 minutes (to a total time of 50 minutes), the change in weight was still occurring, proving that it took longer than 10 minutes for the process of osmosis to occur in the potato. For example, the average percentage mass difference for the large chips in the salt solution for 10 minutes was: –12.85%, whereas after 50 minutes it had gone to: –22.73%. A difference of 9.88%
In my main investigation I needed to make sure it was as fair as it could be. This meant I had to make decisions which would allow my test results to be reliable, and accurate. So I decided what I should change or keep the same in order to achieve this. These are the decisions I have made for the main investigation:

Changes

- I needed to test 5 different solutions to ensure I had a better range of results and ensure I didn't include any outliers.

(0m, 0.5m, 1m, 1.5m, 2m)

- I felt it better to use the larger chips of potato as the results didn't vary as much as the small chips
- I needed to ensure I got the exact weights of all the pieces of potato I would be using in the experiments, and record them on paper and make sure I knew which chip was in which solution.
- I needed to use the same potato for all chips of potato used, which would mean it the potato properties would be the same making the test as fair as it could be
- I also needed to change the amount of time to 60 minutes to allow osmosis to take on a better affect.

The same

- The same amount of liquid (40ml) in each beaker as its an easy amount to work with. It is easy to split into 5 different solutions, and the chips can easily be adapted to fit in the amount of solution allowing osmosis to have an affect on the chips.
- Same type of tissue paper as it seemed to remove the excess water successfully and was easy to use
- Roughly the same weight and size of potato as it showed closely related results
- Same surface area of the chips means they have the same contact with water and the chips are submitted to the same amount of solution all around meaning osmosis has equal affects in all chips.

I believe this will make the main investigation more reliable, and provide a better more accurate understanding of the experiment. The large size potatoes in the preliminary showed closely related results which meant they seemed reliable, and 50 minutes seemed like a reasonable amount of time for osmosis to take place, so I decided to raise the amount of time to see a greater effect of osmosis taking place. More solutions means I have a wider range of results, and by being more accurate in recording the weights before the investigation it means the main investigation will be fair. This makes me feel more confident about the main investigation, and its outcome.

Main investigation

To start the main investigation I first had to gather all the extra equipment I would be needing. This included 5 beakers instead of 2, more salt solution and distilled water, more potato, a scalpel, tissue paper, sensitive scales, and paper and pen to record the results.

The first thing I did was to organise all the equipment to ensure we knew what I were doing, and then I created as many pieces of potato with the cork-borers as was possible. I used the scalpel again to make the pieces as identical as possible, making sure I used the same potato to make it fair. I then set out the 5 beakers and sorted out the solutions for each one.

- **Beaker 1 – 40ml distilled water**
- **Beaker 2 – 10 ml salt solution, 30ml distilled water**
- **Beaker 3 – 20ml salt solution, 20ml distilled water**
- **Beaker 4 –30ml salt solution, 10ml distilled water**
- **Beaker 5 – 40 ml salt solution**

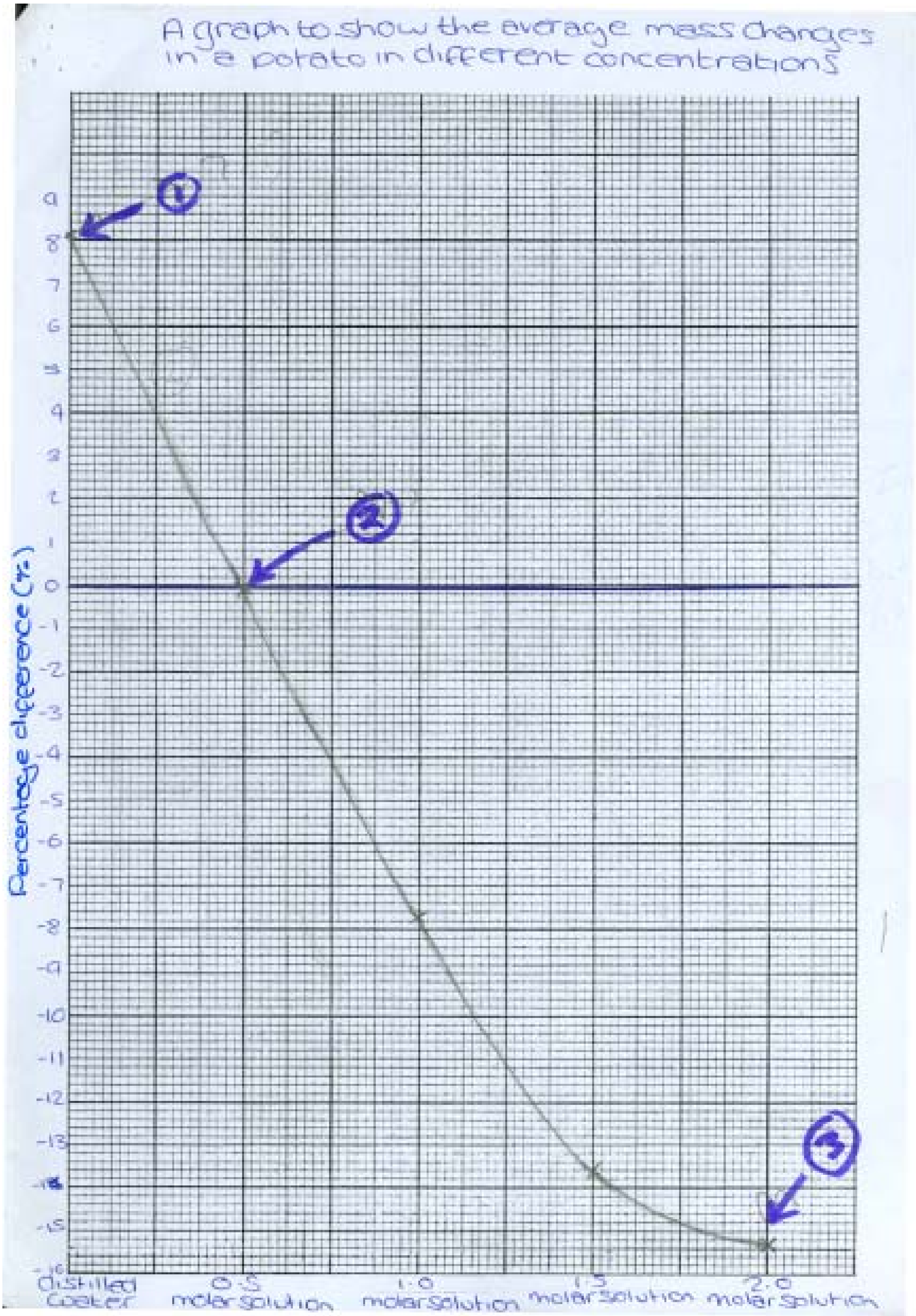
The next thing I did was to pick the 15 best pieces of potato. I then weighed them, and recorded the results, and then set them out ensuring I knew the time we started and which potato was going in which beaker. In each beaker I put 3 pieces of potato.

After leaving them in for the period of time, which was 50 minutes, I took them out and placed them on the tissue paper, I then rolled them out gently ensuring I removed the excess water and then weighed them again and I gathered these results:

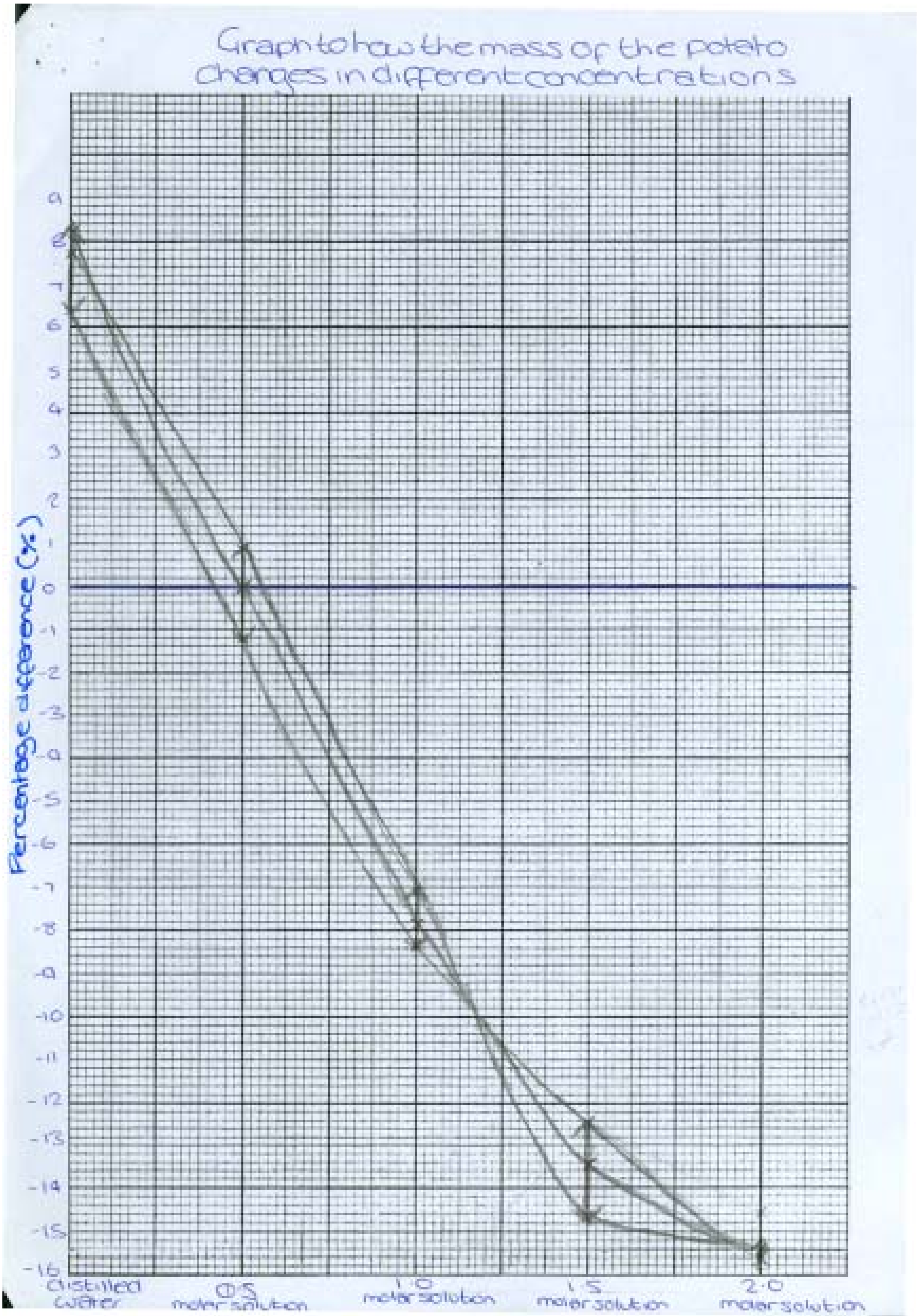
results

Solution		Before (grams)			After (grams)	
0m	5.67	5.71	5.71	6.06	6.19	6.22
0.5m	5.78	5.56	5.70	5.71	5.61	5.70
1m	5.86	5.80	5.80	5.37	5.39	5.34
1.5m	5.83	5.82	5.72	5.10	4.96	4.95
2m	5.82	5.82	5.78	4.91	4.95	4.89

	Mass difference (%)		Average mass difference (%)
+6.44	+7.75	+8.20	+8.07
-1.21	+0.89	+0.00	-0.12
-8.36	-7.07	-7.93	-7.79
-12.52	-14.78	-13.46	-13.59
-15.64	-15.40	-15.40	-15.48



A graph to show the average mass changes in a potato in different concentrations
Percentage difference (%)
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
1
2
3
distilled water
0.5 molar solution
1.0 molar solution
1.5 molar solution
2.0 molar solution

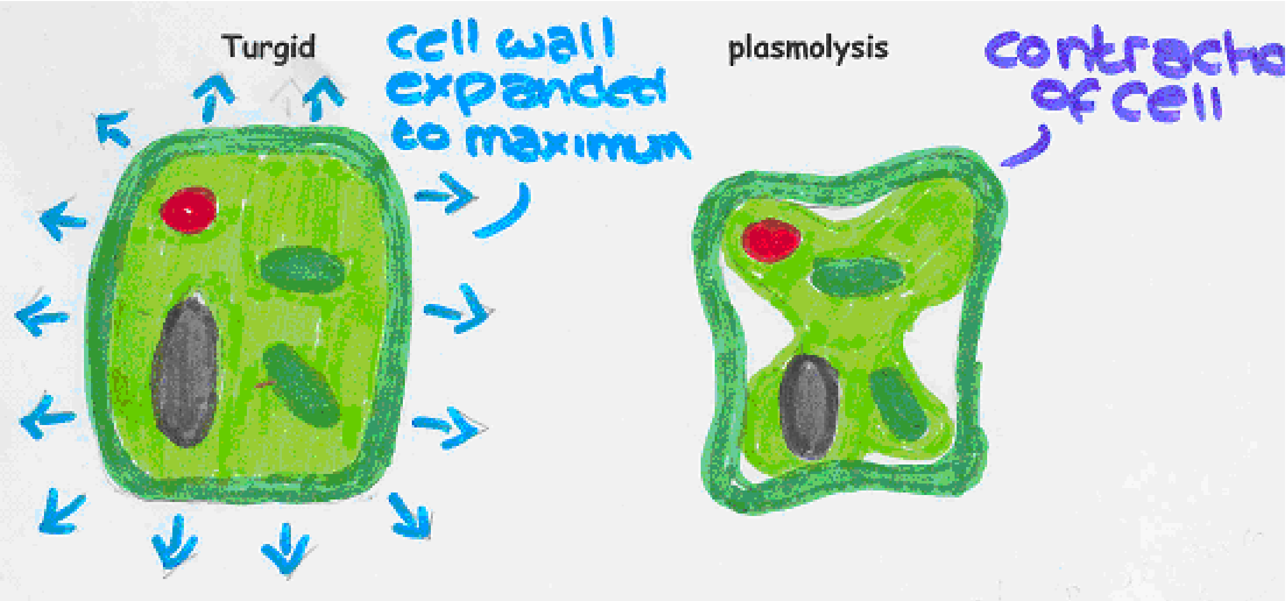

Graph to how the mass of the poteto changes in different concentrations
Percentage difference (%)
distilled water
0.5 molar solution
1.0 molar solution
1.5 molar solution
2.0 molar solution

__My graph__

(1) The top of the line in my graph represents the turgidity of my chips. The concentration of free water molecules being greater on the outside means water will diffuse into the chip. The extra water means the chip swells up until reaching a point were the concentration of water molecules is equal inside and outside the chip which means the mass is greater.

(2) The line the steeply declines from that point, and eventually reaches the point where there is no change in weight at about 0.5 molar solution. This is roughly the point at where the concentration of water molecules in the solution is the same as what is in the potato chip, showing a balance between the two, and there no change in mass as no water is lost or added.

(3) The line continues steeply declining at a similar rate, until roughly the mass percentage difference of –13% in which the line begins to level out showing the start of plasmolysis, and the cell becomes more flaccid. This is where the concentration of water molecules outside the chip is lower than what is inside, and the water will pass through the semi-permeable membrane forcing the contraction of the cell. The cell membrane peels off the cell wall and the vacuole eventually collapses. The error bars vary in sizes, however the one set of results that stands out is the 2 molar solution as they are all within 0.24 of a change to each other, The largest error bar occurs at the 1.5 molar solution where the change goes from 12.52 – 14.78 which is a 2.26 change and would probably be better if repeated.



evaluation

My results are very closely related showing that my results are reliable and the error bars between my results are stable throughout, and they don't show great difference.

I would carry on these concentrations to 3 molar solution instead of 2 molar solution. This would enable me to see if the line is still levelled out and continuing the line at present moment. This would show the point at which plasmosis has happened and when the cell wall has collapsed due to the loss of water. This is the point at which no more water can be lost.

Then by looking into further detail around the area 0.4–0.6 molar solution I could find out more detailed results about the concentration of solution within the chips. This would mean the solution on the outside doesn't transfer of accept any water molecules as the solution inside the chip is balanced.

Commentary on Script A

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity and demand of task								✓		6
	Techniques used							✓			
	Autonomy and independence							✓			
C	Identification and control of interfering factors								✓		7
	Extend and design of data								✓		
	Quality/precision of manipulation								✓		
I	Graphical processing of data							✓			6
	Numerical processing data										
	Summary of evidence						✓				
	Explanations suggested							✓			
E	Evaluation of procedures	✓									4
	Reliability of evidence							✓			
	Reliability of conclusion							✓			
P	Description of work planned and carried out								✓		7
	Recording data								✓		
	Labelling tables and units										
	Observations										
	General quality of communication								✓		
	Overall total mark for the investigation										30

Aspect	Mark	Comment
Strand S: Strategy		
(a)	7	Complex task approached in a thorough and careful way demanding good levels of precision and skill
(b)	6	Selects rather than justifies equipment and techniques used
(c)	6	Topic is not reviewed and appears to be developed from a general brief; salt solutions of particular concentrations appear to have been provided; it would be useful to have teacher annotation in support
Strand C: Collecting Data		
(a)	7	Identifies and controls the main factors that might affect the outcomes; surface area, mass, time of immersion
(b)	7	Good preliminary work to establish the range and time of immersion. Repeat measurements taken. More values of salt concentrations could have been selected around 0.5 M to provide more evidence to answer the investigation question ‘ what is the concentration of the solution in a potato’
(c)	7	From a scrutiny of the results, the differences in the repeat values and the graph the results are generally of good quality; good preliminary work to identify the most appropriate immersion times
Strand I: Interpreting Data		
(a)	7	Graphs drawn with correctly plotted points, axes suitably labelled, best fit line, scatter of measurements for each concentration shown and awareness of errors indicated; clear keys when displaying all the data not shown on graph
(b)	5	Different results are compared and general trend in the data is described; no definite statement regarding shape of the best fit line although ‘levelling out’ is recognised; no formal conclusion specified
(c)	6	Scientific knowledge and understanding is used to explain the results
Strand E: Evaluation		
(a)	0	No evaluation of procedures
(b)	6	Scatter in the results is recognised and related to reliability
(c)	6	Range covered is suggested to be extended; further study around 0.4 to 0.6 is suggested
Strand P: Presentation		
(a)	7	Practical procedures are described clearly and in detail
(b)	7	All data recorded to suitable level of accuracy
(c)	7	Good use of scientific terminology; spelling, punctuation and grammar are generally sound

Investigation of Osmosis

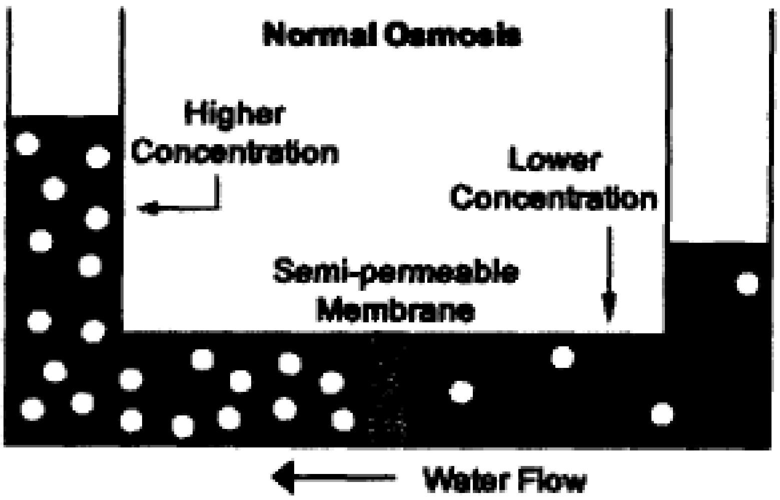
Aim:

My aim for this project is to find out if osmosis affects sucrose when added to water solution with potato chips. Does the potato chip gain weight from osmosis?

Background Knowledge:

Osmosis is the movement of water molecules across a partially permeable membrane from an area of high water concentration to an area of low water concentration.

A partially permeable membrane is a membrane with so small holes that only water molecules can fit through it.



Osmosis is a type of diffusion. As shown on the figure above, the water molecules can pass through the partially permeable membrane both ways, but passes through more on one side. This is because there is more water molecules on one side, this causes a water flow into the area with fewer water molecules. This leaves whatever solution on the other side ‘diluted’ as the water molecules break down the solution.

I will need to have the same temperature and size of potato chip and total of sucrose and water so only the density of water in the solution is different.

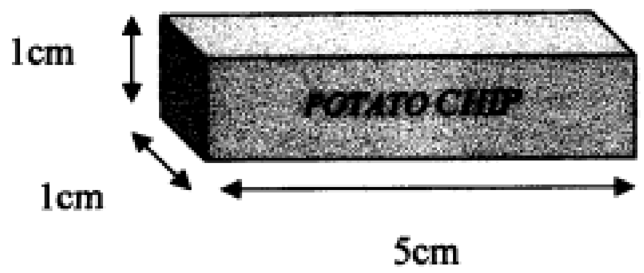
Equipment list:

- 15 test tubes
- 5 test tube racks
- 1 pertry dish
- 2 syringes
- 1 set of scales
- 1 stop watch
- 15 potato chips
- 1 ruler
- 1 knife
- 50 ml of sucrose (For each investigation)
- 50 ml of water (For each investigation)
- Paper towels

Method:

Before I start my investigation I will collect all the equipment needed, I will also use a clear workspace to work on.

First I cut my potato chips to all the same size in order for the investigation to be fair. We chose to cut the chips 5cm by 1cm x 1cm because we tried different sizes and this was the biggest which went in the test tubes and under the sucrose and water.



I then wrapped the potato chips with some paper towels to absorb as much liquid from the potato chips. I set up my test tubes in my test tube racks and measured different measurement of sucrose and water in each tube.

Test	Amount of water (ml)	Amount of sucrose (ml)
1	0	20
2	5	15
3	10	10
4	15	5
5	20	0

For each test I did, I used 3 test tubes (each same amount of sucrose and water). This will make my results more reliable as I would have 3 separate results for each test.

I then weighed each chip in a pitry dish (the dish not included for the weight). By weighing the chips before adding them to the solutions I can see if they have changed in weight when I weigh them again at the end of the experiment.

After the weighing of all 15 potato chips I added each one to their solutions. I took note of which chip went into each test tube so I would know their own weights as each chip varied in mass. I started the timer as the chips were added and waited 45 minutes for the experiment to take place.

After the time was up I took out each chip and weighed them all to see if they had changed in weight. My results of what I found are in the table.

Averages:

Sucrose (ml)	Water (ml)	Mean start weight (grams)	Mean end weight (grams)	Mean difference from start to end	Mean percentage of weight difference
20	0	4.53	3.93	-0.6	-14.5%
15	5	4.27	3.88	-0.39	-9.3%
10	10	4.44	4.28	-0.16	-4%
5	15	4.96	5.1	0.14	3%
0	20	4.24	4.60	0.36	8.7%

Conclusion:

From my results, I have concluded that the chip has a density level between 25% and 50% of sucrose. I know this as the chip placed in the sucrose solution with a higher density than 50% sucrose lost weight due to the fact that the water in the chip passed through the semi-permeable membrane of the chip into the solution due to the fact that in osmosis, water passes from the lower density to the higher density and therefore making the chip lighter and causing it to rise.

Improvements

I could have improved my results by running more tests and keeping the tests in a controlled temperature environment. This would allow the temperature not to effect the process of osmosis. It was hard to make the chips equally dry after the experiment and this might have made the end weight change.

The main improvement I could have made was to make sure all the potato chips were all the same in mass. This would make the water content per chip different and could slightly alter my results. It would make the results clearer.

Commentary on Script B

Title of investigation: Osmosis

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity and demand of task							✓			6
	Techniques used							✓			
	Autonomy and independence							✓			
C	Identification and control of interfering factors						✓				5
	Extend and design of data						✓				
	Quality/precision of manipulation						✓				
I	Graphical processing of data										4
	Numerical processing data					✓					
	Summary of evidence				✓						
	Explanations suggested						✓				
E	Evaluation of procedures						✓				2
	Reliability of evidence	✓									
	Reliability of conclusion	✓									
P	Description of work planned and carried out					✓					4
	Recording data					✓					
	Labelling tables and units										
	Observations										
	General quality of communication						✓				
	Overall total mark for the investigation										21

Aspect	Mark	Comment
Strand S: Strategy		
(a)	6	Task approached in a suitable way requiring care and precision and good quality data to be collected.
(b)	6	Suitable equipment selected and used
(c)	6	Task defined by student from a more general brief. Possible interfering factors are identified and there is some evidence of preliminary work to establish the size of chip to use.
Strand C: Collecting Data		
(a)	5	Identifies size and mass of chip, volume of sugar solution and time of immersion to be controlled. Although in practice the initial masses of the chips varied considerably. Mentions use of paper towels to absorb any excess liquid.
(b)	5	The concentrations of sugar solutions used are appropriate in producing a suitable range of results. The method described shows awareness of the need to repeat measurements at each concentration but the results table only includes the 'mean' values.
(c)	5	No mention of how the volumes of sugar and water are measured. From inspection of results the 'mean' data look of generally good quality but since not all results are shown no judgement can be made regarding reliability.
Strand I: Interpreting Data		
(a)	4	No graphs are drawn but numerical processing of results to determine % mass changes are calculated. However, calculations are not always correct.
(b)	3	By noting differences in the individual results makes an estimate regarding the concentration of the solution in the chip.
(c)	5	Relates this estimate to scientific ideas and knowledge
Strand E: Evaluation		
(a)	5	Shows awareness of some of the limitations of the procedure and identifies the importance of keeping the initial mass of the chip constant and the temperature controlled.
(b)	0	No reference to the quality of the data
(c)	0	No mention of the confidence level of the conclusions.
Strand P: Presentation		
(a)	4	Main features of the method are described but lack detail
(b)	4	Not all the raw data is reported
(c)	5	Spelling, punctuation and grammar are generally sound and mostly the correct scientific terminology is used.

OSMOSIS

Method:

For this investigation, I sliced pieces of potato and put them into a sugar solution of a known strength to see whether the pieces of potato grew bigger or shrunk. I made the sugar solutions by using one molar sugar and water and mixing them together at different concentrations.

See results table.

I weighed the pieces of potato before and after they were introduced to the sugar solutions. They were left in the solution for 24 hours.

The potatoes grew larger depending on how strong the sugar solution is.

The experiment I am doing is to see the changes in mass in pieces of potato in different strengths of solution and water. Once we had set the experiments up we left three pieces of potato in each of the six solutions.

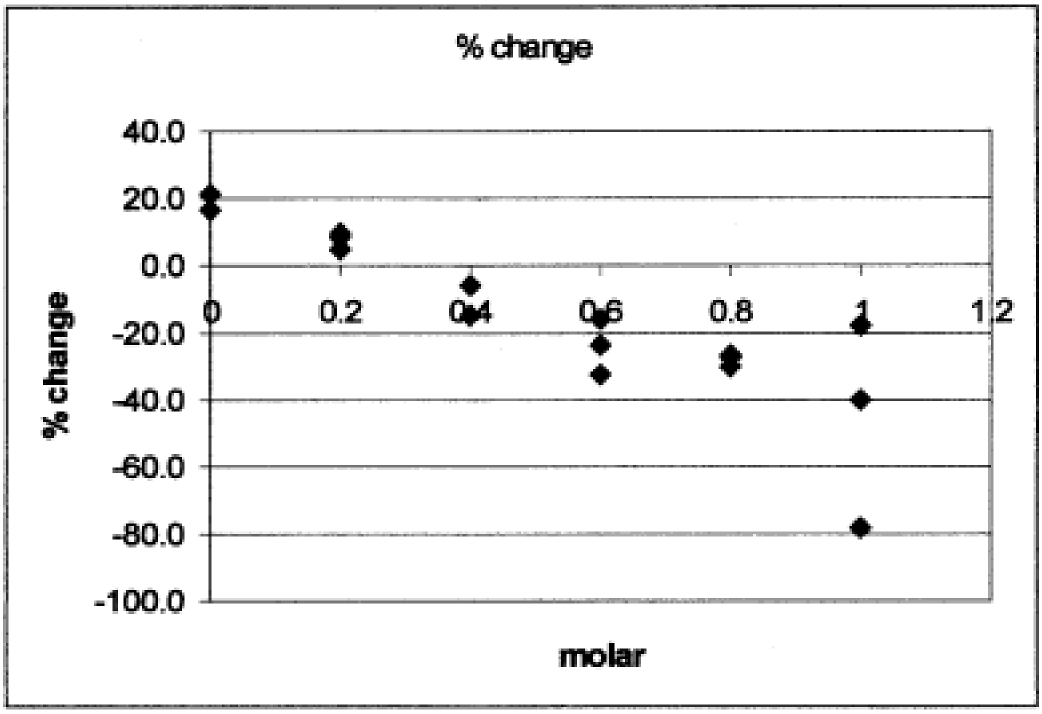
The solution mixture is shown below

30	+	0	=	1M
24	+	6	=	0.8M
18	+	2	=	0.6M
12	+	8	=	0.4M
6	+	4	=	0.2M
0	+	30	=	0M

Results table:

molar	start	end	% change
1.0	6.11	1.32	78.4
	2.82	1.70	39.7
	1.81	1.49	17.7
0.8	3.38	2.46	27.2
	4.50	3.32	26.2
	3.23	2.27	27.7
0.6	2.80	1.90	32.1
	2.33	1.78	23.6
	2.27	1.91	15.9
0.4	4.27	3.64	14.8
	2.77	2.61	5.8
	2.97	2.80	5.7

0.2	3.47	3.63	4.6
	3.02	3.27	8.2
	3.76	4.11	9.3
0	3.59	4.19	16.7
	2.77	3.36	21.3
molar	2.83	3.43	21.2



Evaluation:

I think that the experiment I did went well but there are some aspects that I could have done better. For example, I should have weighed the pieces of potato again to make sure it was an accurate reading.

Commentary on Script C

Title of investigation: Osmosis

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity and demand of task						✓				
	Techniques used					✓					4
	Autonomy and independence					✓					
C	Identification and control of interfering factors		✓								
	Extend and design of data							✓			3
	Quality/precision of manipulation				✓						
I	Graphical processing of data										
	Numerical processing data						✓				2
	Summary of evidence	✓									
	Explanations suggested	✓									
E	Evaluation of procedures			✓							
	Reliability of evidence	✓									1
	Reliability of conclusion	✓									
P	Description of work planned and carried out				✓						
	Recording data					✓					4
	Labelling tables and units										
	Observations										
	General quality of communication						✓				
	Overall total mark for the investigation										14

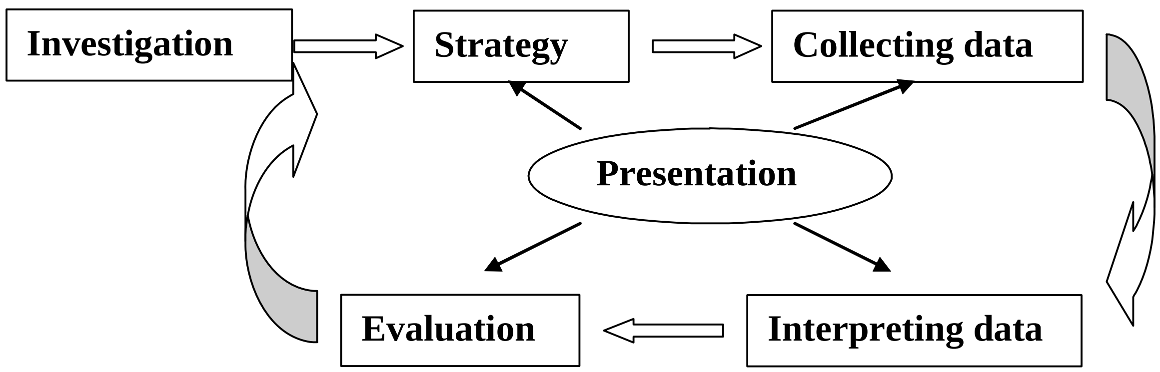
Aspect	Mark	Comment
Strand S: Strategy		
(a)	5	From results obtained the candidate has approached the task in a suitable way to obtain a wide range of data
(b)	4	Little information provided regarding the method involved apart from measuring masses
(c)	4	From information provided by the centre the task is defined by the candidate from a more general brief but help was given
Strand C: Collecting Data		
(a)	1	The total volume of each solution is the same, the initial masses for each concentration are different and no other information is provided; no awareness of the need for control described
(b)	6	Large range of data collected and repeat measurements made.
(c)	3	Data of variable quality; some repeats indicate significant variation and no awareness of reliability issues is shown anywhere in the report.
Strand I: Interpreting Data		
(a)	5	A computer generated graph is drawn including all the data but no line of best fit is included
(b)	0	No trend given
(c)	0	No explanation attempted
Strand E: Evaluation		
(a)	2	Makes a relevant comment about how the data was collected
(b)	0	No comment regarding reliability of the evidence
(c)	0	No comment regarding the reliability of the conclusion
Strand P: Presentation		
(a)	3	The purpose of the work is stated but the key features of the experimental procedures are missing
(b)	4	Labelling of columns in the table of results is inadequate and units are missing but all raw data is recorded
(c)	5	Spelling, punctuation and grammar are of variable quality; use of appropriate scientific vocabulary is limited

Appendix J: Guidance for Students - Investigations

During this science course, you will be asked to design experiments to investigate many practical questions. The assessment of the course includes marks for how well you can complete an investigation. Any of the investigations you do could be used to judge these marks. The mark you are given at the end of the course will be the total mark for your most successful investigation.

This part of the investigation counts for one-third of the total marks for the whole subject, so it is really worth-while learning how to carry out and record investigations as well as possible.

For the assessment, marks are awarded for each of five ‘strands’ in the investigation:



Each strand is marked out of 8 marks so the maximum mark possible is 40.

Read through and consider the following advice and guidance.

Strategy (Strand S)

Do not rush this part; your whole investigation depends on how good your strategy is!

- Your teacher will introduce investigations which could be used for assessment. You may be allowed some choice of what to investigate, and you have to decide how to set about the task!
- Look at the information in the topic(s)/module(s) that is (are) relevant to your investigation. Find out what sort of things (factors) might affect the results you get.
- If you ask your teacher what to do then you might not be able to obtain the highest marks in this strand. The more ideas you have yourself the higher marks you might be able to achieve. If you write the title to your investigation in terms of a question this sometimes helps to provide a clear focus for your work and makes you answer it when writing your conclusion!

Initial method

- Think about the factors involved; select the one you are going to change and how you are going to control the others. Think about the range of values you are going to use for the factor that you might change.
- Think about how to make sure that the data you collect is accurate and reliable so that you have good quality evidence on which to base your conclusion. Write down your thoughts.

- Do some preliminary work to get a ‘feel’ for what you will do before committing yourself to a detailed plan.
- Include reasons why you have selected the particular apparatus that you have done. Draw diagrams as appropriate. If you are only using simple apparatus and techniques then you may be limiting yourself to the maximum mark that you can obtain.
- Record your results, do an initial interpretation and evaluation and modify your method as appropriate.

Collecting Data (Strand C)

Make sure you keep a record of all your results, including results of preliminary tests

- Describe the factors involved.
- Identify the factor you are going to investigate and record the measurements of the others that you have controlled.
- On the basis of your preliminary work include the range of values you have chosen for the factor you are changing.
- Make sure that the data you collect includes enough measurements, is accurate and reliable, repeating any measurements that you think necessary, so that you have data of the best quality.
- Record your data in a suitably labelled table, paying attention to units and numbers of significant figures.
- Whilst you are doing the experiment think about any problems that you having and note them down for the evaluation stage.

Interpreting Data (Strand I)

Process your data, identify patterns, draw conclusions and explain them using your scientific knowledge and understanding

- Process your data by doing some analysis using calculations and/or plotting your data on a line graph. Consider the errors on each point, drawing error bars if you can before you draw a line of best fit. Is the best fit line straight, a curve or something else? You can produce a graph using a computer but it is probably best to draw the line of best fit yourself. If a line graph is not appropriate then draw a histogram, bar chart or scatter graph.
- Record trends and patterns in your data doing mathematical calculations if this helps in any comparisons that you make.
- Make a conclusion and try to express it in a quantitative way if this is appropriate.
- Look carefully at the scatter in your data to see if it limits your conclusion in anyway.
- Explain your conclusion using your scientific knowledge and understanding.

Evaluation (Strand E)

This area is generally regarded as the most difficult. It is probably best to focus on your data and methods separately and then discuss any limitations and confidence levels you have in your conclusion pointing out what further data you could collect.

Evaluating the data that you have collected

- How many results did you collect – were these enough to draw a conclusion?
- How accurate were your results?
- Do all your results clearly fit a trend/pattern or do some look wrong e.g. look at your graph, the best fit line and identify any anomalous results.
- Are there any results that you think should be repeated?
- If some of your results didn't fit the trend/pattern can you explain why?
- Look at the differences between your repeat measurements. Are the differences important or do you think your results are sufficiently reliable?
- Does your conclusion explain all your results or did you leave some out?
- Have your results covered a big enough range to support a firm conclusion?
- Have you collected a sufficient number of accurate and reliable results to support a firm conclusion?

Evaluating your method/procedure

- Did you have any problems with your method?
- Was your equipment appropriate for the task?
- How well did you control the other factors that you didn't investigate- did they vary during the experiment?
- How precise were your results e.g. did you judge by eye or use an instrument?
- How big were the divisions on the scale of the equipment and were they adequate for the readings needed?
- How accurate can the readings be from the equipment you used?
- What improvements to your method would you suggest to make the results more accurate and reliable?

Reliability of conclusion

- What extra measurements might you do to make your conclusion more certain?

Presentation (Strand P)

Your report must be organised and presented clearly with full details of all aspects of your investigation using relevant scientific words with good spelling, punctuation and grammar.

- Make sure that your tables of data have suitable headings with units and your data is correctly recorded to the appropriate degree of accuracy with the correct numbers of significant figures.

- Make sure your graph has a title, is of a suitable size (no miniature Excel graphs), labelled axes with units and points correctly plotted.

Investigation checklist

Strategy	• Topic(s) reviewed and investigation suggested • Investigation is of appropriate complexity • Strategy includes attention to accuracy and reliability • Equipment and techniques are justified
Collecting data	• Factors involved identified and either controlled or varied • Range of values of factor under investigation established from preliminary work • Modifications to method made if required • Data collected is sufficient, accurate and reliable • Anomalous results repeated
Interpreting data	• Data is processed using graphs or mathematical methods • Graphs have axes labelled, correct units, accurate plotting, line of best fit and estimate of errors • Mathematical methods involve comparisons between results and possibly statistical or inverse relationships • Trends and patterns identified in the results • Qualitative or quantitative relationships stated as a conclusion • Limitations to the conclusion due to scatter in results are identified • Conclusion explained using scientific knowledge and understanding
Evaluation	• Problems in method affecting quality of results are described • Improvements to method are suggested and justified • Results are assessed for accuracy and reliability • Anomalous results are identified and explained • Level of confidence in the conclusion is described
Presentation	• Aim of investigation is clear • Report is well organised with all procedures described in detail • Observations and measurements are fully and clearly recorded with labelling and units correct • Data recorded to appropriate degree of accuracy • Scientific terminology is relevant and correctly used • Spelling, punctuation and grammar are correct.

Appendix K: Cover Sheet for Work for Moderation of Case Study and Data Analysis

OCR RECOGNISING ACHIEVEMENT	Biology A **Twenty first century science** Subject J633 Skills assessment Unit A229	**200_**

Centre No: | | | | | | Centre Name: ____________

Candidate No: | | | | | Candidate Name: ____________

A229 Marks for data exercise (strands I and E)

Title of activity (as shown on the work): ……………………………………………………………………………….

Use ticks in the boxes (one per row) to indicate the level of performance as judged by the centre, and enter the mark awarded for each strand. The final two columns must be left blank for the moderator.

Strand	Aspect of the work	0	1	2	3	4	5	6	7	8	Strand mark	Mod	T/L
I	Graphical display **or** Processing data												
	Summary of evidence												
	Explanations												
E	Evaluation of procedures												
	Reliability of evidence												
	Reliability of conclusion												

Tick here if these marks are taken from the **same** activity which is counted for assessment of the Investigation in Additional Science. ☐

A229 Marks for the Case Study:

Title of the Case-study (as shown on the script): …………………………………………………………………….

Use ticks in the boxes (one per row) to indicate the level of performance as judged by the centre, and enter the mark awarded for each strand. The final two columns must be left blank for the moderator.

Strand	**Aspect of the work**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Strand mark**	**Mod**	**T/L**
A	Planning use of sources												
	Acknowledgements												
	Internal referencing												
B	Using science knowledge												
	evaluating scientific evidence												
C	Comparing arguments												
	Conclusions												
D	Structure and organisation												
	Visual communication												
	Quality of language												

Centre overall total mark		Moderator overall total mark		Difference	

Appendix L: Cover Sheet for Work for Moderation of Investigation

	Biology J633 Unit A230 Investigation	200_

Student Name: ……………………………………………… Candidate No: ………………

Title of Investigation: …………………………………………………………… Date: ……………………

Marked by: ………………………………………………… Centre No: …………………..

This completed form should be attached to the front of the investigation report

Strand	Aspect of performance	Level of performance related to mark descriptors									Mark	Moderator
		0	1	2	3	4	5	6	7	8		
S	Complexity & demand											
	Techniques chosen											
	Autonomy/independence											
C	Control of other factors											
	Range & design of data											
	Quality of manipulation											
I	Graphical display											
	Processing data											
	Conclusions											
	Explanations											
E	Evaluating procedures											
	Evaluating the data											
	Judging reliability											
P	Description of the work											
	Recording data											
	Labeling and units											
	Qualitative observations											
	Quality of communication											

Moderator comments

Total mark (sum of strand marks)		

Appendix M: Support for Very Weak Students to Produce Coursework

Value of preparation for weak candidates

The preparation of extra materials and the careful administration needed to support very weak candidates should be given a high priority within the Science Department, because these resources can also be used in cases of extended staff absence, or for candidates who miss the normal opportunities for preparing their coursework in lessons. As the coursework is worth a high proportion of the marks for the whole GCSE it is very important that all candidates attempt every component.

Organising the work

A strict timetable improves the pace of work. A clear, achievable outcome for each lesson builds confidence and makes supervision and guidance much more manageable. An A4 or A3 tick chart for each group can be displayed and updated to confirm completion of each outcome and to indicate work that is incomplete or missing.

Collecting all work in each lesson for checking helps to ensure an appropriate rate of progress. Rough work should also be collected as it may prove useful later. Support staff can help to ensure that all work is named and handed in. A brightly-coloured and clearly labelled folder for coursework emphasizes its value and significance.

It is important to check that individual Support staff understand the internal assessment; and especially that they understand that it is the candidates' own ideas that are being assessed, so that telling them what to write, may stop them from getting marks.

Case Study

The case study allows weak candidates to be given very structured tasks, with guidance. The assessment criteria take account of the extent of guidance provided whilst crediting the work of the candidate.

Choosing a topic

Candidates will be better motivated if they have some choice, but in order to provide adequate support for weak candidates this needs to be limited to a couple of titles. When the coursework is first introduced, a short list of possible titles can help to illustrate the idea of the project. A brief class discussion of these titles to select the two most popular can give more ownership to the project. The short listed titles must refer to an issue which is familiar to the candidates so they can understand the extra information they find whilst producing their report. They need to refer to science explanations (Strand B), so it is better for the topics to be based on science ideas which are important in the Units.

The best title is a question which demands an answer, so the candidates have a clear target of deciding on their own answer to the question.

For example, the title 'Should smoking be banned?' has been successful for weak candidates.

Strand A: Quality of selection and use of information

Aspect (a) planning the use of sources of information

A case study for a weak candidate could be based on one or two paper sources of information. Preparing the information in advance of starting the case study makes it much easier to manage the task. It is important to avoid a classroom situation where some pupils cannot proceed with their work because they do not have access to information that they understand.

Two or three websites could be suggested to the candidates for them to select illustrations and /or further information.

This would allow them to gain a mark in Strand A.

The information given to them should include:

- the science explanations for the topic;
- an opinion for the suggestion or question in the title, with a reason for this opinion;
- an opinion against the suggestion or question in the title, with a reason for this opinion.

Aspect (b) acknowledgement of sources used

This is not expected of the weakest candidates.

Aspect (c) linking information to specific sources

This is not expected of the weakest candidates.

Strand B: Quality of understanding of the case

Aspect (a) making use of science explanations

It is unlikely that weak candidates will be able to tell which parts of a science topic are relevant to the case they are studying, but it would help them to describe a relevant science topic; for example, for a case study on smoking, a revision lesson could cover the respiratory and circulatory systems.

The key scientific words and phrases for the topic should be listed so candidates can learn them and use them correctly when writing their report.

Aspect (b) recognition and evaluation of scientific evidence

It is safer for the candidates' understanding of the case if the stimulus material includes scientific evidence rather than unsupported claims, as weak candidates find the distinction difficult.

If candidates enter a blog site that discusses a contentious issue, they are likely to find many unsupported claims. Caution is needed in using such sites because unsupported claims and opinions could make too deep an impression, especially if expressed by peers.

Strand C: Quality of conclusions

Aspect (a) comparing opposing evidence and views

Very weak candidates may be unable to recognize whether ideas that are opposed to, or linked to, different points of view. Other candidates may recognize this, but have difficulty in articulating their views. They may be helped by physical means of sorting information from their extracts; for example by cutting out statements and sorting into different envelopes, by using distinct colours of paper on which to paste or write the information, or by highlighting using different colours.

Aspect (b) conclusions and recommendations

If the coursework title is a question with a yes / no answer, then candidates can provide a yes / no answer as their conclusion.

Once the conclusion is written, candidates can be asked to add a reason for their view.

Strand D: Quality of presentation

Aspect (a) structure and organisation of the report

The case study can be structured by the use of worksheets or writing frames which can guide them through the process so that their efforts are linked to the criteria by which they are assessed. They need to include: an introduction, explaining why they have chosen the topic; the science involved in the topic; the arguments for and against the issue; and their own conclusion.

Aspect (b) use of visual means of communication

Two or three websites can be suggested to the class, where they can find suitable illustrations for their work. It may be better to do this once the written work is complete, in order to avoid distractions.

Aspect (c) spelling, punctuation and grammar

A revision lesson can be used to remind candidates of the key words for the topic and a literacy-based homework could be set so they can practice using these words. They should be reminded of the importance of correct spelling and punctuation and reminded to use the spell checker if using a word processing package. If the work is to be hand written, writing on alternate lines leaves space for corrections and improves the appearance of the Report.

Data Analysis

Weak candidates need a familiar topic for this task so that they know how to collect the data and how to interpret the results. Whilst only strands I and E are assessed, the experience from the Pilot shows that students need to be involved in planning and carrying out the test so they can understand the scientific ideas before interpreting the data.

Worksheets with detailed writing frames can be used to guide candidates through each stage in their work, but the work for assessment must be their own.

It is important to check that individual support staff understand the internal assessment; and especially that they understand that it is the candidates' own work that is being assessed, so that doing work for them, may stop them from getting marks. It would be helpful to have clear instructions on how to support individuals who may have particular difficulties with practical tasks.

Choosing a topic

The work should involve a very simple practical task. The meaning of the results should be very clear to the candidates; for example, if you soak a piece of potato in a glucose solution, its mass changes. It is better to avoid tasks where candidates have to think about the meaning of the quantity they measure; for example, measuring pH; because if they do not understand the scientific idea, they cannot interpret the results.

Strand I: Interpreting Data

The candidate's data should be part of the data set used for this it can be supplemented by the data from other members of the class.

Aspect (a) graphical or numerical processing of data

The candidates must display results in a table, chart or graph. A template for a graph, with the appropriate axes and scales, can be prepared by the teacher and duplicated for use by weaker candidates.

Aspect (b) summary of evidence

The candidate needs to compare the results from two different situations. Two individual results can be compared.

The differences in the results must be recorded.

Aspect (c) explanations suggested

Weak candidates struggle to explain their observations using scientific knowledge. They should be encouraged first to write an explanation based on previous experience. When that has been completed, they could describe simply the scientific idea underpinning the test.

In the case of the leaking can, this would be the fact that pressure increases with depth and that that more pressure causes a faster flow.

If they succeed in relating the conclusion to scientific ideas the score would be higher than a mark of 2.

Strand E: Evaluation

Aspect (a) evaluation of procedures

Most candidates find it hard to evaluate their procedures and very weak candidates may be unable to make a comment about the how the data was collected. They could be helped by being given incomplete sentences to finish, and rewarded with a single mark for doing this successfully.

Aspect (b) reliability of evidence

Candidates can be prompted into writing an opinion by being given a menu of options, for example, 'I think my data is very reliable / reliable / not very reliable. They could then be asked to give a reason for their opinion. A sensible opinion, which does not refer appropriately to the data, would be worth 2 marks.

Aspect (c) reliability of conclusion

A question such as 'Are you sure your conclusion is right?' can be used to help candidates consider the reliability of their conclusion. This can be followed with other questions, for example, 'What did you do, to make sure you got a good result?'

Pilot Centres have found the Evaluation to be the hardest part of the task and weak candidates have often scored 1 in this Strand.

Investigation

Choosing a topic

The work should involve a very simple practical task. The meaning of the results should be very clear to the candidates; for example, if you soak a piece of potato in a glucose solution, its mass changes. It is better to avoid tasks where candidates have to think about the meaning of the quantity they measure; for example, measuring pH; because if they do not understand the scientific idea, they cannot interpret the results.

Organising the work

Allow a series of at least six lessons to prepare for the investigation. In this time several candidates are likely to have short absences, and the rate of progress will vary, so careful management is needed.

One example of a suitable investigation is to study a ‘leaking container’. The rate of flow of water out of a hole in a container depends on the water level above the hole. This works well with a large (300 ml) polystyrene drinking cup with a small puncture hole in its base. It is filled with water and the water which leaks out in 30 seconds is collected when the cup is full, half full and almost empty. The time of 30 seconds does not demand quick reactions for the timing and collection, but is not too long for keeping attention on the task. Water with food dye added could be provided for easier measurements.

In the introductory lesson, the scientific ideas should be revised. In this case these would be ideas about pressure. It would be sensible to give the opportunity to practice using appropriate vocabulary such as ‘pressure’, ‘depth’, ‘force’ and ‘gravity’. The idea of ‘rate’ is very difficult so it is better to talk about how much water leaks out in a set time. A demonstration such as the ‘water fountain’ could be used to link these ideas with the ideas of the investigation.

A low-level explanation of the observed effects can be based on prior experience, so the introductory lesson should always include demonstrations of the effect to be studied and reminders of any everyday applications which may be familiar to the students.

Strand S: Strategy

A task like this can be based on highly structured worksheets. If the candidate follows these instructions, they can gain credit at 2 marks if the work is of very limited precision or reliability.

Strand C: Collecting data

Each candidate must record their own data. Make sure no-one relies on a friend to do this, and ensure that the data is collected for safe keeping. If candidates follow the given practical procedure and record their own results, they may earn 2 marks in Strand C.

It is advisable for the teacher to prepare some sets of data for use in Strands I and E as it is likely that the data collected by weak candidates may not be good enough to interpret.

Strand I: Interpreting data

The candidate’s own work should ideally be used for this, but it may be of very poor quality; the teacher’s data should then be used as well as, or instead of, the candidate’s results.

Aspect (a): graphical or numerical processing of data

The candidates must display results in a table, chart or graph. A template for a graph, with the appropriate axes and scales, can be prepared by the teacher and duplicated for use by weaker candidates.

Aspect (b): summary of evidence

The candidate needs to compare the results from two different situations. Two individual results can be compared.

The differences in the results must be recorded.

Aspect (c): explanations suggested

Weak candidates struggle to explain their observations using scientific knowledge. They should be encouraged first to write an explanation based on previous experience. When that has been completed, they could describe simply the scientific idea underpinning the test.

In the case of the leaking can, this would be the fact that pressure increases with depth and that that more pressure causes a faster flow.

If they succeed in relating the conclusion to scientific ideas the score would be higher than a mark of 2.

Strand E: Evaluation

Aspect (a) evaluation of procedures

Most candidates find it hard to evaluate their procedures and very weak candidates may be unable to make a comment about the how the data was collected. They could be helped by being given incomplete sentences to finish, and rewarded with a single mark for doing this successfully.

Aspect (b) reliability of evidence

Candidates can be prompted into writing an opinion by being given a menu of options, for example, ‘I think my data is very reliable / reliable / not very reliable. They could then be asked to give a reason for their opinion. A sensible opinion, which does not refer appropriately to the data, would be worth 2 marks.

Aspect (c) reliability of conclusion

A question such as “Are you sure your conclusion is right?’ can be used to help candidates consider the reliability of their conclusion. This can be followed with other questions, for example, ‘What did you do, to make sure you got a good result?’

Pilot Centres have found the Evaluation to be the hardest part of the Investigation and weak candidates have often scored 1 in this Strand.

Strand P: Presentation

Very weak candidates will need worksheets or writing frames to remind them to include all aspects of their task in their report. At the level of two marks, complete descriptions are not expected.

The assessment is on the communication skills used to present the work. Many candidates like to make their work look pleasing, and this can encourage them to work carefully. However, they are not assessed on the appearance of the report.

Aspect (a) description of work planned and carried out

The description of the work has been attempted, but is incomplete.

Aspect (b) recording of data

The data has been recorded, but labelling, units and observations may be incomplete.

Aspect (c) general quality of communication

Candidates should be encouraged to use the scientific words relevant to the test, and to check their work for spelling errors. However, at the level of 2 marks there is no penalty if they are unsuccessful.

Appendix N: Ideas about Science

In order to deal sensibly with science as we encounter it in everyday life, it is important not only to understand some of the fundamental scientific explanations of the behaviour of the natural world, but also to know something about science itself, how scientific knowledge has been obtained, how reliable it therefore is, what its limitations are, and how far we can therefore rely on it – and also about the interface between scientific knowledge and the wider society.

The kind of understanding of science that we would wish pupils to have by the end of their school science education might be summarised as follows:

The aim of science is to find explanations for the behaviour of the natural world. A good explanation may allow us to predict what will happen in other situations, and perhaps to control and influence events.

There is no single 'method of science' that leads automatically to scientific knowledge. Scientists do, however, have characteristic ways of working. In particular, data, from observations and measurements, are of central importance.

One kind of explanation is to identify a correlation between a factor and an outcome. This factor may then be the cause, or one of the causes, of the outcome. In complex situations, a factor may not always lead to the outcome, but increases the chance (or the risk) of it happening. Other explanations involve putting forward a theory to account for the data. Scientific theories often propose an underlying model, which may involve objects (and their behaviour) that cannot be observed directly.

Devising and testing a scientific explanation is not a simple or straightforward process. First, we can never be completely sure of the data. An observation may be incorrect. A measurement can never be completely relied upon, because of the limitations of the measuring equipment or the person using it.

Second, explanations do not automatically 'emerge' from the data. Thinking up an explanation is a creative step. So, it is quite possible for different people to arrive at different explanations for the same data. And personal characteristics, preferences and loyalties can influence the decisions involved.

The scientific community has established procedures for testing and checking the findings and conclusions of individual scientists, and arriving at an agreed view. Scientists report their findings to other scientists at conferences and in special journals. Claims are not accepted until they have survived the critical scrutiny of the scientific community. In some areas of enquiry, it has proved possible to eliminate all the explanations we can think of but one – which then becomes the accepted explanation (for the time being).

Where possible scientists choose to study simple situations in order to gain understanding. But it can then be difficult to apply this understanding to complex, real-world situations. So there can be legitimate disagreements about how to explain such situations, even where there is no dispute about the basic science involved.

The application of scientific knowledge, in new technologies, materials and devices, greatly enhances our lives, but can also have unintended and undesirable side-effects. An application of science may have social, economic and political implications, and perhaps also ethical ones. Personal and social decisions require an understanding of the science involved, but also involve knowledge and values beyond science.

This is, of course, a simplified account of the nature of science, which omits many of the ideas and subtleties that a contemporary philosopher or sociologist of science might think important. It is intended as an overview of science in terms which might be accessible to 14-16 year old candidates, to provide a basic understanding upon which those who wish may later build more sophisticated understandings. It is important to note that the language in which it is expressed may well not be that which one would use in talking to candidates of this age.

The following pages set out in more detail the key ideas that such an understanding of science might involve, and what candidates should be able to do to demonstrate their understanding.

Data and their limitations

Data are the starting point for scientific enquiry – and the means of testing scientific explanations. But data can never be trusted completely, and scientists need ways of evaluating how good their data are.

	Ideas about science	A candidate who understands this…
1.1	Data are crucial to science. Explanations are sought to account for known data, and data are collected to test proposed explanations.	uses data rather than opinion in justifying an explanation
1.2	We can never be sure that a measurement tells us the true value of the quantity being measured.	can suggest reasons why a measurement may be inaccurate
1.3	If we make several measurements of the same quantity, the results are likely to vary. This may be because we have to measure several individual examples (e.g. the height of cress seedlings after 1 week), or because the quantity we are measuring is varying (e.g. amount of ozone in city air, time for a vehicle to roll down a ramp), and/or because of the limitations of the measuring equipment or of our skill in using it (e.g. repeat measurements when timing an event).	can suggest reasons why several measurements of the same quantity may give different results when asked to evaluate data, makes reference to its reliability (i.e. is it repeatable?)
1.4	Usually the best estimate of the value of a quantity is the average (or mean) of several repeat measurements.	can calculate the mean of a set of repeated measurements from a set of repeated measurements of a quantity, uses the mean as the best estimate of the true value can explain why repeating measurements leads to a better estimate of the quantity
1.5	The spread of values in a set of repeated measurements give a rough estimate of the range within which the true value probably lies.	can make a sensible suggestion about the range within which the true value of a measured quantity probably lies **can justify the claim that there is/is not a ‘real difference’ between two measurements of the same quantity**
1.6	If a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect.	can identify any outliers in a set of data, and give reasons for including or discarding them

Correlation and Cause

Scientists look for patterns in data, as a means of identifying possible cause-effect links, and working towards explanations.

	Ideas about science	A candidate who understands this…
2.1	It is often useful to think about processes in terms of factors which may affect an outcome (or input variable(s) which may affect an outcome variable).	in a given context, can identify the outcome and the factors that may affect it in a given context, can suggest how an outcome might be affected when a factor is changed
2.2	To investigate the relationship between a factor and an outcome, it is important to control all the other factors which we think might affect the outcome (a so-called 'fair test').	can identify, in a plan for an investigation of the effect of a factor on an outcome, the fact that other factors are controlled as a positive feature, or the fact that they are not as a design flaw **can explain why it is necessary to control all factors thought likely to affect the outcome other than the one being investigated**
2.3	If an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	can give an example from everyday life of a correlation between a factor and an outcome
2.4	A correlation between a factor and an outcome does not necessarily mean that one causes the other; both might, for example, be caused by some other factor.	uses the ideas of correlation and cause appropriately when discussing historical events or topical issues in science **can explain why a correlation between a factor and an outcome does not necessarily mean that one causes the other, and give an example to illustrate this**
2.5	In some situations, a factor increases the chance (or probability) of an outcome, but does not invariably lead to it, e.g. a diet containing high levels of saturated fat increases an individual's risk of heart disease, but may not lead to it. We also call this a correlation.	can suggest factors that might increase the chance of an outcome, but not invariably lead to it can explain that individual cases do not provide convincing evidence for or against a correlation
2.6	To investigate a claim that a factor increases the chance (or probability) of an outcome, we compare samples (e.g. groups of people) that are matched on as many other factors as possible, or are chosen randomly so that other factors are equally likely in both samples. The larger the samples the more confident we can be about any conclusions drawn.	can evaluate the design for a study to test whether or not a factor increases the chance of an outcome, by commenting on sample size and how well the samples are matched **can use data to develop an argument that a factor does/does not increase the chance of an outcome**
2.7	Even when there is evidence that a factor is correlated with an outcome, scientists are unlikely to accept that it is a cause of the outcome, unless they can think of a plausible mechanism linking the two.	**can identify the presence (or absence) of a plausible mechanism as significant for the acceptance (or rejection) of a claimed causal link**

Developing Explanations

Scientific explanations are of different types. Some are based on a proposed cause-effect link. Others show how a given event is in line with a general law, or with a general theory. Some theories involve a model, which may include objects or quantities that cannot be directly observed, which accounts for the things we can observe.

	Ideas about science	A candidate who understands this…
3.1	A scientific explanation is a conjecture (a hypothesis) about how data might be accounted for. It is not simply a summary of the data, but is distinct from it.	can identify statements which are data and statements which are (all or part of) an explanation; can recognise data or observations that are accounted for by, or conflict with, an explanation.
3.2	An explanation cannot simply be deduced from data, but has to be thought up imaginatively to account for the data.	can identify imagination and creativity in the development of an explanation.
3.3	A scientific explanation should account for most (ideally all) of the data already known. It may explain a wide range of observations. It should also enable predictions to be made about new situations or examples.	can justify accepting or rejecting a proposed explanation on the grounds that it: • accounts for observations; • **and/or provides an explanation that links things previously thought to be unrelated;** • **and/or leads to predictions that are subsequently confirmed.**
3.4	Scientific explanations are tested by comparing predictions made from them with data from observations or experiments.	can draw valid conclusions about the implications of given data for a given explanation, in particular: • recognises that an observation that agrees with a prediction (derived from an explanation) increases confidence in the explanation **but does not prove it is correct**; • recognises that an observation that disagrees with a prediction (derived from an explanation) indicates that either the observation or the prediction is wrong, **and that this may decrease our confidence in the explanation.**
3.5	For some questions that scientists are interested in, there is not yet an answer.	can identify a scientific question for which there is not yet an answer, **and suggest a reason why.**

The Scientific Community

Findings reported by an individual scientist or group are carefully checked by the scientific community before being accepted as scientific knowledge.

	Ideas about science	A candidate who understands this…
4.1	Scientists report their findings to other scientists through conferences and journals. Scientific findings are only accepted once they have been evaluated critically by other scientists.	can describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists; can recognise that new scientific claims which have not yet been evaluated by the scientific community are less reliable than well-established ones.
4.2	Scientists are usually sceptical about findings that cannot be repeated by anyone else, and about unexpected findings until they have been replicated.	can identify absence of replication as a reason for questioning a scientific claim; **can explain why scientists regard it as important that a scientific claim can be replicated by other scientists.**
4.3	Explanations cannot simply be deduced from the available data, so two (or more) scientists may legitimately draw different conclusions about the same data. A scientist's personal background, experience or interests may influence his/her judgments. (e.g. data open to several interpretations; influence of personal background and experience; interests of employers or sponsors).	can suggest plausible reasons why scientists involved in a scientific event or issue disagree(d).
4.4	A scientific explanation is rarely abandoned just because some data are not in line with it. An explanation usually survives until a better one is proposed. (e.g. anomalous data may be incorrect; new explanation may soon run into problems; safer to stick with ideas that have served well in the past).	**can suggest reasons for scientists' reluctance to give up an accepted explanation when new data appear to conflict with it.**

Risk

Every activity involves some risk. Assessing and comparing the risks of an activity, and relating these to the benefits we gain from it, are important in decision making.

	Ideas about science	A candidate who understands this…
5.1	Everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	can explain why it is impossible for anything to be completely safe can identify examples of risks which arise from a new scientific or technological advances can suggest ways of reducing specific risks
5.2	We can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	can interpret and discuss information on the size of risks, presented in different ways.
5.3	To make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	**can discuss a given risk, taking account of both the chance of it occurring and the consequences if it did**
5.4	People are often willing to accept the risk associated with an activity if they enjoy or benefit from it. We are also more willing to accept the risk associated with things we choose to do than things that are imposed, or that have short-lived effects rather than long-lasting ones.	can suggest benefits of activities that have a known risk can offer reasons for people's willingness (or reluctance) to accept the risk of a given activity can discuss personal and social choices in terms of a balance of risk and benefit
5.5	If you are not sure about the possible results of doing something, and if serious and irreversible harm could result from it, then it makes sense to avoid it (the 'precautionary principle').	**can identify, or propose, an argument based on the 'precautionary principle'**
5.6	Our perception of the size of a risk is often very different from the actual measured risk. We tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and things whose effect is invisible (like ionizing radiation).	**can distinguish between actual and perceived risk, when discussing personal and social choices** **can suggest reasons for given examples of differences between actual and perceived risk**
5.7	Reducing the risk of a given hazard costs more and more, the lower we want to make the risk. As risk cannot be reduced to zero, individuals and/or governments have to decide what level of risk is acceptable.	**can explain what the ALARA (as low as reasonably achievable) principle means and how it applies in a given context**

Making Decisions about Science and Technology

To make sound decisions about the applications of scientific knowledge, we have to weigh up the benefits and costs of new processes and devices. Sometimes these decisions also raise ethical issues. Society has developed ways of managing these issues, though new developments can pose new challenges to these.

	Ideas about science	A candidate who understands this…
6.1	Science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	In a particular context, can identify the groups affected and the main benefits and costs of a course of action for each group
6.2	Scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	can explain the idea of sustainable development, and apply it to specific situations
6.3	In many areas of scientific work, the development and application of scientific knowledge are subject to official regulations and laws (e.g. on the use of animals in research, levels of emissions into the environment, research on human fertility and embryology).	shows awareness that scientific research and applications are subject to official regulations and law
6.4	Some questions, such as those involving values, cannot be addressed by scientists.	can distinguish questions which could be addressed using a scientific approach, from questions which could not
6.5	Some applications of science have ethical implications. As a result, people may disagree about what should be done (or permitted).	where an ethical issue is involved, can: • say clearly what this issue is • summarise different views that may be held
6.6	In discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the majority of people involved. Another is that certain actions are unnatural or wrong, and should not be done in any circumstances. A third is that is that it is unfair for a person to choose to benefit from something made possible only because others take a risk, whilst avoiding that risk themselves.	in a particular context, can identify, and develop, arguments based on the ideas that: • the right decision is the one which leads to the best outcome for the majority of people involved • certain actions are never justified because they are unnatural or wrong
6.7	In assessing any proposed application of science, we must first decide if it is technically feasible. Different decisions on the same issue may be made in different social and economic contexts.	**in a particular context, can distinguish what can be done (technical feasibility), from what should be done (values)** **can explain why different courses of action may be taken in different social and economic contexts**

Appendix O: Advice to Centres on Preparation of Sample for Moderation

Specification J633: Assessment units A229 and A230

This note is to remind you of the stages in preparation of a sample of coursework for moderation. If you have any further queries about coursework, or any aspect of the assessment, please contact the science team, tel. 01223 553311.

The notes which follow summarise the materials and evidence required for moderation of the coursework assessment, and explain how to use the documentation which is also enclosed.

<u>Unit A229: Data analysis + case-study</u>

Each candidate is required to complete a data interpretation and evaluation exercise and a Case-study. The evidence for these will consist of a report of the interpretation and evaluation, and the completed case study report. In each case, candidates may complete more than one, but the final mark is the mark for the best single piece of work. It is not permitted to aggregate part marks from different pieces of work.

The centre will be provided with self-carboning mark sheets (MS1). Enter the overall total mark (one data analysis + one case-study). The top copy of the completed MS1 form is sent to OCR, the second copy to the moderator, to arrive not later than 15th May, and the third copy is retained by the centre.

The moderator will ask for the work of a sample of candidates. The work of these candidates should be sent as quickly as possible to the moderator. The list will identify the names and candidate numbers for each candidate whose work is required by the moderator. This list may be kept to provide a record for you of what work has been sent.

The sample sent to the moderator should contain:

- Brief notes about the activities used for assessment.
- A description of procedures used within the centre to ensure internal standardisation of marking
- The sample of work (one case study and one data exercise) for each candidate in the sample.
- A completed cover-sheet for each candidate in the sample.

<u>Recording of marks for assessed work</u>

The cover sheet may be photocopied to make sufficient copies to provide for each candidate in the sample. The sheet should be used by the teacher to record marking decisions when marking the work. The pages in each piece of work should be stapled together. A paper-clip provides a convenient way of linking the piece of work and the completed mark sheet.

It is essential that a completed sheet is sent for each sample of work which is called for moderation. Enter the centre name and number and the candidate name and number at the top of the sheet.

The sheet also includes spaces which should be left blank. These will be used as a working document by the moderator when checking the work. The sheets will be retained by OCR as a complete record of all judgments related to the moderation.

The centre should also keep its own record of the work done and marks awarded.

‘Double counting’ of marks for the data exercise

For candidates who are also taking Additional Science A (J631) it is permissible to use an investigation from Additional Science to provide the marks for data interpretation and evaluation. If the same piece of work is called for from both specifications, tick the space on the cover-sheet to indicate this. Copies of the work should be included in both Single and Additional Science samples of work.

Special consideration candidates

If a special consideration application regarding internally assessed marks has been made for any candidate, the work of the candidate(s) concerned should be added to the sample, with a note to explain that they are for special consideration.

The sample of work will be returned to the centre, normally early in July. A report on the moderation will be sent with the notification of results.

I hope that these guidelines are clear and will help the process of moderation to run smoothly. Please do not hesitate to get in contact if you have any queries.

Unit A230: Practical Investigation

Each candidate is required to complete a practical investigation. The evidence for this will consist of a written report. Candidates may complete more than one Investigation, but the final mark is the mark for the best single piece of work. It is **not** permitted to aggregate part marks from different pieces of work.

The centre will be provided with self-carboning mark sheets (MS1). The top copy of the completed MS1 form is sent to OCR, the second copy to the moderator, to arrive not later than 15th May, and the third copy is retained by the centre.

The moderator will ask for the work of a sample of candidates. The work of these candidates should be sent as quickly as possible to the moderator. The list will identify the names and candidate numbers for each candidate whose work is required by the moderator. This list may be kept to provide a record for you of what work has been sent.

The sample sent to the moderator should contain:

- Brief notes about the activities used for assessment.
- A description of procedures used within the centre to ensure internal standardisation of marking
- The sample of work (one investigation) for each candidate in the sample.
- A completed cover-sheet for each candidate in the sample.

Recording of marks for assessed work

The cover sheet may be photocopied to make sufficient copies to provide for each candidate in the sample. The sheet should be used by the teacher to record marking decisions when marking the work. The pages in each piece of work should be stapled together. A paper-clip provides a convenient way of linking the piece of work and the completed mark sheet.

It is essential that a completed sheet is sent for each sample of work which is called for moderation. Enter the centre name and number and the candidate name and number at the top of the sheet.

The sheet also includes spaces which should be left blank. These will be used as a working document by the moderator when checking the work. The sheets will be retained by OCR as a complete record of all judgments related to the moderation.

The centre should also keep its own record of the work done and marks awarded.

‘Double counting’ of marks for the data exercise

For candidates who are also taking Science A (J630) it is permissible to use the investigation to provide the marks for data interpretation and evaluation. If the same piece of work is called for from both specifications, tick the space on the cover-sheet to indicate this. Copies of the work should be included in both Single and Additional Science samples of work.

Special consideration candidates

If a special consideration application regarding coursework marks has been made for any candidate, the work of the candidate(s) concerned should be added to the sample, with a note to explain that they are for special consideration.

The sample of work will be returned to the centre, normally early in July. A report on the moderation will be sent with the notification of results.

I hope that these guidelines are clear and will help the process of moderation to run smoothly. Please do not hesitate to get in contact if you have any queries.

Appendix P: Candidate Authentication Statement

OCR

RECOGNISING ACHIEVEMENT

Candidate Authentication Statement

The completed form should be retained within the Centre and should not be sent to the moderator or OCR unless specifically requested.

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.

If you copy from someone else or allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

1. Any help or information you have received from people other than your subject teacher(s) must be clearly identified in the work itself.
2. Any books, information leaflets or other material (e.g. videos, software packages or Information from the Internet) which you have used to help you complete this work must be clearly acknowledged in the work itself. To present material copied from books or other sources without acknowledgement will be regarded as deliberate deception.

Declaration by candidate

Centre name ____________________ Centre No [| | | |]

Session ____________________ Year [| | |]

Specification of Unit title ____________________

Candidate Name ____________________ Candidate Number [| | |]

I have read and understood the **Notice to Candidate** (above). I have produced the work without any help from other people apart from that which I have declared in the work itself.
I have acknowledged all source materials in the work itself.

Candidate's signature:

Date:

Notes:

The Candidate Authentication statement once completed should be stored securely within the centre. A copy of this authentication form must be available upon request for each coursework/portfolio submission.

Standard Candidate Authentication Statement

Appendix Q: Centre Authentication Form

OCR
RECOGNISING ACHIEVEMENT

Centre Authentication Form

OCR Advanced GCE GCSE Entry Level

One copy of this form must be completed for **each** unit or coursework component and signed by the appropriate person(s). The completed form **must** accompany the coursework or portfolios submission to the moderator/examiner or be inspected by the visiting moderator for Entry Level, GCSE, GNVQ, VCE and GCE qualifications.

It is now a requirement of the Code of Practice that this authentication form is signed.

*'**Authentication of candidates' work** – The internal assessor must present a written declaration that the candidates' work was conducted under the required conditions as laid down by the specification.'*

Centre Name ______________________ **Centre No** | | | | | |

Specification or Unit title ______________________

Qualification or Unit number/component code | | | | | | |

Session ______________________ **Year** | 2 | 0 | 0 | |

Moderated unit
(Please tick box if yes) ☐ *In this case this form must accompany the sample posted to the moderator or inspected by the visiting moderator*

or

Examined unit
(Please tick box if yes) ☐ *In this case this form must accompany the packet of coursework which is posted to the examiner or assessed by the visiting examiner.*

Signature(s) of internal assessor(s) – i.e. person(s) responsible for carrying out internal assessment and/or supervision (in the case of examined coursework) of work:

I/We the undersigned confirm that the candidates' work was conducted under the required conditions as laid down by the specification.

Signature:.. Print name:..

Signature:.. Print name:..

Signature:.. Print name:..

Please continue on a separate sheet if required.

In order to support internal assessors in authenticating their students' work an **example** of a standard Candidate Authentication Statement is provided on the OCR Website (www.ocr.org.uk). Alternatively centres may wish to continue to use their own internal arrangements for candidate authentication, but these must provide equivalence to the standard Candidate Authentication Statement.

Notes

In the case of private candidates or distant tutored candidates, the centre must ensure that:

- *the tutor/teacher has acquainted themselves thoroughly with the general standard of candidates' work before accepting coursework for Internal Assessment. Work submitted by candidates that is atypical or inconsistent with their general standard may raise concerns over authenticity.*
- *sufficient on-going regular monitoring of the candidates' examination coursework has taken place.*
- *Centres are reminded that they must comply with restrictions that may apply to entries e.g. the exclusion of Private candidates from a specification.*

CCS160 Revised July 2005 **Centre Authentication Form**

Oxford Cambridge and RSA Examinations

Appendix R: Health and Safety Information

In UK law, health and safety is the responsibility of the employer. For most centres entering candidates for GCSE examinations this is likely to be the Local Education Authority or the Governing Body. Teachers have a duty to co-operate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of Safety in Science Education. For members, the CLEAPSS guide, Managing Risk Assessment in Science offers detailed advice.

Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X;

Topics in Safety 3rd edition, 2001, ASE ISBN 0 86357 316 9;

Safeguards in the School Laboratory, 10th edition, 1996, ASE ISBN 0 86357 250 2;

Hazcards, 1995 with 2004 updates, CLEAPSS School Science Service*;

CLEAPSS Laboratory Handbook, 1997 with 2004 update, CLEAPSS School Science Service*;

CLEAPSS Shorter Handbook (CLEAPSS 2000) CLEAPSS School Science Service*;

Hazardous Chemicals, A manual for Science Education, (SSERC, 1997) ISBN 0 9531776 0 2.

*Note that CLEAPSS publications are only available to members or associates.

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual Centre then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely.

The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc.

There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

When candidates are planning their own investigative work the teacher has a duty to check the plans before the practical work starts and to monitor the activity as it proceeds.