National Council for Curriculum and Assessment
An Chomhairle Náisiúnta Curaclaim agus Measúnachta

Junior Certificate Science

Draft Guidelines for Teachers

Updated February 2006

FOREWORD

The Junior Certificate science syllabus is the definitive document in relation to syllabus topics and sub-topics, and the learning to be achieved as specified in the associated learning outcomes.

These draft guidelines support the implementation of the syllabus by providing teachers with a broader context for science education in the junior cycle, together with specific ideas and suggestions for classroom practice that can facilitate students in developing their knowledge, understanding, skills and attitudes in relation to science. Teachers should choose an appropriate teaching methodology for the achievement of the aims, objectives and learning outcomes specified in the syllabus.

The guidelines, which were made available initially in electronic format only, complement the programme of in-service education for teachers, through which additional teaching resources are made available—see the support service website at http://www.juniorscience.ie.

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1. Introduction

A new kind of syllabus

The revised syllabus in Junior Certificate science replaces the syllabus that had been in place since 1989, when the Junior Certificate was introduced. While much of the content of the previous syllabus has been retained, the revised syllabus differs from its predecessor in three significant ways. First, the revised syllabus has a different structure to its predecessor. The core and extensions model, which was adopted in 1989 to accommodate the scope of the former Intermediate Certificate and Day Vocational Certificate science courses, was seen as contributing to under-emphasis of the chemistry and physics aspects of science in the junior cycle, especially at Ordinary level. In revising the syllabus, a simplified structure was adopted through which students would be required to study each of the three major areas of science: biology, chemistry and physics.

Secondly, the revised syllabus places student learning in the context of science activities, emphasizing hands-on engagement through which the students can develop their understanding of the scientific concepts and principles involved, together with appropriate science process skills. This approach provides greater coherence with the science education that students experience in the primary school. There is an increased emphasis on an investigative approach, through which students can develop an understanding and appreciation of activities and processes that are fundamental to all science, together with the ability to apply science principles in their everyday lives.

Thirdly, the revised syllabus adopts a different style of presenting the science course. Previously, material was presented as a list of content (facts, definitions, laws, lists of properties, etc.) which it was intended would be taught and learned "with an emphasis on student experience of science as a practical activity" (science syllabus, 1989). However, there was no explicit indication of the desired learning outcomes to be associated with this content. With international trends moving to focus more on the student as learner and, in particular, on the specification of desired outcomes of his/her learning, the science topics in the revised syllabus are accompanied by a set of learning outcomes, which encompass the knowledge, understanding and skills that students can be expected to attain through their study of science. The focus is on achieving the intended outcomes, regardless of the approach taken. The manner in which these are presented affords the teacher flexibility in designing appropriate experiences for students so that the desired learning can take place and the learning experiences can be matched to the abilities and interests of the students. Possible ideas for teaching and learning are presented in section 5 of these guidelines.

A change in approach to teaching and learning science

Over a number of years, concerns have been expressed at the declining interest in science, particularly the physical sciences. This has been noticeable in the senior cycle and also at third level. The kinds of science experiences that junior cycle students had in schools and the manner in which the course enabled some aspects of science to be omitted were identified as contributing to a fall-off in the take-up of physics and chemistry at senior cycle, with follow-on impact at third level. Furthermore, the approach to science that was included in the revised primary school curriculum differed significantly from that in the junior cycle. These factors were taken into consideration in revising the Junior Certificate science syllabus.

The revised syllabus places increased emphasis on scientific investigation and on the application of science process skills through student activities. The overall length of the syllabus is such that time is allowed for active student engagement in learning experiences that will enable the development of science process skills, leading to a better understanding of the underlying science concepts, as well as the development of higher-order skills associated with problem solving and the application of knowledge in new situations or contexts. This is in keeping with international developments in science education, reflecting a move towards greater emphasis on the development of scientific literacy.

Science and its many applications play an increasingly important role in our lives and, as citizens, we need to become scientifically literate in order to engage with issues that arise from developments in science and technology. We need to understand, in a general way, the processes of science so that we are in a position to evaluate the advantages and disadvantages of these developments and their potential impact on our lives and environment. While it is not the only means of doing so, the study of science contributes to the development of thinking and decision-making skills that can be used in problem-solving. Such skills can be developed through the systematic approach to investigations which is a feature of science, and they can be easily transferred to other, non-scientific situations and contexts.

Science, technology and society (STS) context

Participation in discussion of science and science-related issues has extended beyond the boundaries of the classroom and the science laboratory. It is no longer confined to academic interests or purely to scientific concepts. This is not surprising, given the pervasive nature of the applications of science in our everyday lives. It is important, therefore, to develop the skills and understanding that enable engagement with such everyday issues.

Using a science-technology-society (STS) approach in the teaching and learning of Junior Certificate science will facilitate the students' understanding of science, while at the same time linking the learning of science to contexts and issues in their everyday lives and environment. Students can develop in a real-life context the scientific knowledge, skills, concepts and attitudes essential for the responsibilities of citizenship in today's world.

While there is no explicitly prescribed STS content in the syllabus, many of the sub-topics and associated learning outcomes require appropriate linkage to everyday experiences (in areas such as health, diet, human development, ecology) and to everyday examples of applications of science (such as in biotechnology, industry, medicine, energy conservation, electronics, etc.). The exemplars given later in the guidelines (see section 4) illustrate how a variety of contexts familiar to students can be used to lead into, and follow-on from, the teaching and learning of syllabus topics. They can offer a starting point to engage students' interest or to generate points for subsequent discussion or development.

Appropriate reference to the work of prominent scientists and to modern scientific developments can provide points of transference from school-based learning to general experience, making scientific phenomena more meaningful for the students.

Changed approach supported through assessment

In the revised syllabus, many of the learning outcomes are associated with practical activities which students must undertake. Effecting a movement towards 'doing' rather than simply 'observing' or 'learning off' science was one of the main reasons for revising the syllabus. The presence of mandatory activities and student investigations for which credit is given in the assessment arrangements reflects this changed approach. The revised syllabus sees the introduction of a second assessment component in the form of coursework, for which students can obtain up to 35% of the overall assessment marks. The investigative approach and the application of science process skills are strongly reflected in the coursework, particularly in the coursework B investigations. The examination paper, which accounts for the remaining 65% of the marks, also reinforces and rewards the investigative approach and the application of science process skills, including their use in relevant contexts (see section 6 for further details on assessment).

The role and aims of the guidelines

Given the inclusion of extensive learning outcomes in the revised syllabus, and the putting in place of a full-time support service to assist teachers in engaging with them, the role of these guidelines differs from those developed to support the introduction of the previous science syllabus.

These guidelines complement the professional development provided for teachers and the web-based resources that are being developed to support the implementation of the revised syllabus. They set the teaching of science in a wider educational context and suggest teaching approaches and activities that are not meant to be prescriptive, but that teachers may find useful. They should be used in conjunction with the syllabus when planning the teaching and learning of science, so that due emphasis is given to the investigative, hands-on approach to learning science which is adopted in the revised syllabus, as well as setting the learning of science in contexts that are meaningful to students. Specific exemplars are included that illustrate how teachers can plan student learning experiences for a given topic, from its introduction in an appropriate context though classroom or laboratory activities that promote active student engagement in learning, and follow-through to assess the extent of the learning that has taken place.

Furthermore, the guidelines identify activities or learning experiences that may be used to enable students for whom it may be appropriate, or who may have a particular interest in specific topics, to gain additional insights into science. The aims of these guidelines are to

- help teachers understand the changed emphasis in the revised syllabus and to familiarise them with its structure and with the specified topics and learning outcomes
- place the teaching and learning of Junior Certificate science within the broader contexts of the study of science at primary level and in the senior cycle
- advise on teaching strategies or approaches, with suggestions for a variety of teaching and learning activities
- support teachers in planning the investigations and activities required by the learning outcomes specified in the syllabus
- support teachers in the development of a school policy on science as part of School Development Planning
- indicate ways in which learning in science may be linked to other learning experiences in the junior cycle and to the everyday lives of students.

Science in the primary school

As part of the Primary School Curriculum (1999), all children study science. The science curriculum was implemented in all schools from September 2003, following an initial pilot phase in a limited number of schools. The study of science at primary level is placed in the context of social, environmental and scientific education (SESE), thus promoting its relevance to children's experience and facilitating the development of informed attitudes towards scientific and environmental issues.

Primary science has its roots in nature study and environmental studies, and builds on children's interests and curiosity about the biological and physical world, while at the same time incorporating experimental and investigatory skills in their work. Experience of the biological and physical world is crucial to children's cognitive development. In this way, objects and events can be experienced and encountered in reality before they become the subject of thought and mental manipulation. Children in primary schools construct scientific ideas and concepts based on available evidence. These ideas and concepts will be refined as the children work in more demanding contexts and develop more open-ended investigative approaches to solving problems.

Science at second level

In the junior cycle, the study of science contributes to a broad and balanced educational experience for students, extending their experiences at primary level. Science education in the post-primary junior cycle is concerned with the development of scientific literacy and associated science process skills, together with an appreciation of the impact that science has on our lives and environment. In an era of rapid scientific and technological change, the study of science is fundamental to the development of the confidence required to deal with the opportunities and challenges that such change presents in a wide variety of personal and social contexts.

Arising out of their experience in the junior cycle, it is hoped that many students will be encouraged to study one or more of the science subjects in the senior cycle, thus preparing themselves for further study or work in this area. The five science subjects in the Leaving Certificate are: agricultural science, biology, chemistry, physics, and physics and chemistry (combined). The syllabuses in biology, chemistry and physics have recently been revised.

Junior Certificate science

The revised syllabus in Junior Certificate science emphasises a practical experience of science for the student. The syllabus presentation does not imply any particular method or sequence of teaching science, although it should follow a logical and coherent approach. In the teaching and learning of science, appropriate links should be made between the three syllabus sections. A wide range of teaching approaches may be used, including the use of datalogging where appropriate. Particular emphasis should be put on the everyday applications of science in the student's life and environment, and appropriate reference should be made to the work of prominent scientists and to modern scientific developments. These represent the points of transference from school-based learning to general experience.

Teaching strategies should promote the aims, objectives and learning outcomes described in the syllabus and they should include investigative work as well as experimental work. Practical activities are, therefore, an essential element of the course. There should be an emphasis on the development of investigative process skills as well as on the thought processes of science and the knowledge content. Active learning experiences can lead to a better understanding, while at the same time developing skills and attitudes.

The approach and methods adopted in teaching this syllabus should enable and encourage both teachers and students to achieve its aims and objectives. The learning experiences of students must reflect their everyday lives, thus developing awareness of the applications of science in their lives and environment, together with a sense of safety in the laboratory, at home, in the workplace, and in the environment.

2. Course structure and levels

Syllabus topics are presented under three main headings—biology, chemistry and physics—each of which is sub-divided into three sections, as illustrated in the table below.

1. Biology	1A Human biology – food, digestion and associated body systems
	1B Human biology – the skeletal/muscular system, the senses and human reproduction
	1C Animals, plants and micro-organisms
2. Chemistry	2A Classification of substances
	2B Air, oxygen, carbon dioxide and water
	2C Atomic structure, reactions and compounds
3. Physics	3A Force and energy
	3B Heat, light and sound
	3C Magnetism, electricity and electronics

Errata in the syllabus

A number of minor errors have been identified in the syllabus (both English and Irish versions). Some of the errors found in the English version were corrected in the Irish version.

Reference	Errata/Corrections
OB23, p. 11	The initial words 'recall that' should not be underlined. The underlined section should extend to include the words 'and that', thereby leaving the non-underlined part of this learning outcome as follows: recall that urine is stored in the bladder before being released from the body.
OB38, p. 15	The initial words 'understand how to' should be deleted so that this learning outcome reads as follows: use a simple key to identify plants and animals, including vertebrates and invertebrates
OB43, p. 15	The word 'indicate' in line four should read 'indicating'.
OB56, p. 15	The entire outcome should be underlined (i.e. Higher level only); the word 'radical' should read 'radicle'.
OC15, p. 19	This learning outcome should not be underlined (see 2A7).
Introduction, p. 20	The introductory sentence should read: Air, oxygen, carbon dioxide and water are important chemicals in our everyday lives.
OC39 p. 23	The term 'atomic mass' should read 'relative atomic mass'.

Erratum in Irish version of the syllabus

Reference	Erratum/Correction
3A6, p. 26	'foinsí fuinnimh inathnuaite nó neamh-inathnuaite' omitted from the sub-topics.

Overview of the assessment arrangements

Within each syllabus section, topics and sub-topics are listed, together with associated learning outcomes. The learning outcomes embody the investigative approach emphasised in the revised syllabus and form the basis of the assessment arrangements.

Junior Certificate science will be assessed at two levels, Higher and Ordinary. At each level, assessment will be by means of a terminal examination paper and coursework. The assessment arrangements are illustrated below.

Coursework A		**Coursework B**		**Terminal examination**
Experiments and investigations specified in the syllabus	+	Additional specified investigations or one investigation of the student's own choice	+	Section 1: Biology Section 2: Chemistry Section 3: Physics
Marks: 10%		Marks: 25%		Marks: 65%

Coursework A – mandatory experiments and investigations

In each of the main sections of the syllabus, ten experiments or investigations are identified as mandatory (indicated in bold print in the syllabus). These represent a minimum of practical work. Each student must keep his/her own individual record of these thirty activities over the three years of the course, and this must be available for inspection. As part of the assessment, marks will be awarded on a pro rata basis for the satisfactory completion of this coursework.

Coursework B – student assignments

In the third year of the course, students will be required to carry out two specified investigations, which will be based on the topics and learning outcomes in the syllabus. These will be set by the State Examinations Commission and will vary for each yearly cohort of examination candidates. As an alternative to the set investigations, a student may substitute a single investigation of his/her own choosing, provided that it meets the criteria laid down by the State Examinations Commission.

Terminal examination paper

There will be separate Ordinary level and Higher level examination papers, each with three sections corresponding to the structure of the syllabus. The examination papers will assess the candidates' knowledge and skills in relation to topics and learning outcomes in the syllabus.

Further details on assessment, including exemplars of the different types of questions that are recommended, can be found in section 6 of these guidelines.

3. Skills and processes of science

Use of measuring instruments

It is important from the outset to ensure that students are familiar with and correctly use basic apparatus when, for example, reading volume, measuring length, mass, etc. They should be encouraged to take accurate readings, and to record all measurements, using appropriate units.

Observation

It is by means of observation that we gain much information about the world around us. The skill of observation needs to be developed if students are to study natural phenomena and form opinions or make judgements about naturally occurring objects and events. Students should be encouraged to

(a) use all of their senses, each where appropriate

(b) assess quantitatively – size, weight, etc.

(c) note changes, patterns or trends

(d) observe only what is there and avoid making inappropriate inferences.

Classification can be used to show relationships between things or for identification purposes. It is usually based on the fact that objects/substances/organisms/reactions share common characteristics or properties. Students can classify by

- careful observation of objects or events
- identification of similar or dissimilar characteristics or properties
- grouping of objects or events on the basis of their observations of chosen characteristics or properties.

Examples might include classification of plants and animals, acids and bases, or insulators and conductors.

Communication

Students should develop the ability to convey information accurately. Communication skills can be

(a) oral/aural: through discussion and verbal reporting of observations, facts and conclusions

(b) graphical: by use of diagrams, graphs, tables, etc.

(c) written: by recording observations, describing procedures (for example, steps taken in an experiment), recording results and conclusions.

For effective communication, information must be accurate and clearly presented, using the language of science as appropriate. Students should be encouraged to develop their understanding and use of correct scientific terms.

Planning and designing investigations

Designing investigations involves the application of a scientific method, which will in practice incorporate many, if not all, of the skills and processes of science. Initially, the teacher will have a central role to play in leading students, through guided discovery, to develop their own skills of planning and designing investigations.

An investigation involves a step-by-step procedure:

(i) defining the problem and forming a prediction or hypothesis

(ii) planning the investigation and controlling variables where appropriate

(iii) testing/carrying out the investigation and observing/recording

(iv) interpreting the results and drawing conclusions.

(i) Defining the problem/forming a hypothesis

The problem may arise from a number of sources, for example, observation, class discussion, previous work, reading or from an everyday situation.

The student is required to think about or pose questions such as: 'What might happen if ... ?'. For example, if a student has been studying evaporation he/she may ask why some clothes dry more quickly than others. This leads to other questions: is it the type of material?… is it the weather?, and so on.

From these questions it may become clear that there are a number of factors (variables) involved. The student cannot test all of these together, so a hypothesis may be stated; for example, the type of material affects the evaporation rate.

(ii) Planning the investigation/identifying and controlling variables

The student must now decide how the hypothesis will be tested or investigated, and select the appropriate apparatus and procedures. Thus, continuing with the ‘clothes’ example above, to measure the rate implies timing how long it takes for the materials to dry.

It is important for the student to understand the concept of a fair test. Suppose the student hung a nylon sheet outdoors and a cotton sheet indoors and, having observed both over a period of time, found that the nylon sheet dried first. What conclusions can the student draw? Why did the nylon sheet dry first – was it the nature of the material as was first suggested or had the temperature, sunlight or wind any influence? These questions cannot be answered, since there are too many variables; that is, it was not a fair test. The relevant variables must be noted and controlled. In this investigation the student should have placed both materials in identical conditions of sunlight, temperature, breeze, etc. Any difference in drying time, and thus evaporation rate, can then be attributed to the nature of the material, which is the only other variable.

It should be noted that the question of multiple variables may not always arise.

(iii) Testing/carrying out the investigation/recording data

This involves carrying out the required practical procedures using suitable apparatus correctly and with due regard to safety. Appropriate measurements and/or observations must be made and recorded accurately. Results need to be organised and presented clearly so that their meaning can be evaluated. Use of tables, trend graphs, and bar charts may help in the recording of the data or observations.

(iv) Interpreting results and drawing conclusions

To interpret or explain the results the student should

(a) look for common patterns or trends, relationships between factors or variables

(b) relate results or patterns to prior knowledge

(c) relate results to the original hypothesis

(d) generalise where necessary.

The student should then be able to reach a conclusion.

In some cases the results may be inconclusive, so it may be necessary to re-examine the methods used or carry out further investigations.

4. Teaching methodology

The fundamental principle underpinning any teaching and learning strategy is that it should enable the aims, objectives and learning outcomes of the syllabus to be achieved. These guidelines are intended to support a teaching strategy that is syllabus led rather than textbook led. As already noted, the revised syllabus places increased emphasis on an investigative approach to science. Thus, the teaching strategy adopted must involve the student as an active participant, developing the skills required for working scientifically, while at the same time developing associated knowledge, understanding and attitudes. A variety of strategies can be followed, depending on a range of school, teacher and student factors. Some of these are considered below.

Science can be made more meaningful for students if appropriate contexts are used. As already noted, a science-technology-society approach can enable students to link their learning in science to everyday experiences and to the many applications of science that impact on their lives and environment. Exemplars of lesson planning are provided later in this section which illustrate approaches that may be used when introducing a topic.

The sequence of sections and sub-sections in the syllabus is not intended to represent a prescribed order for teaching science. Rather, the teacher should select an appropriate combination and sequence of topics to suit the abilities of the students in the class, and should choose a pace of learning that presents an achievable, but challenging target. Thus, for example, a teacher might choose to group together topics from different sections that relate to a common science concept such as energy, or link associated topics under a common theme such as water treatment.

It is recommended that science teachers in a school co-operate in the planning of learning experiences for their students, thus facilitating the shared use of equipment and resources, common class or school tests, etc. When planning teaching and learning activities, due consideration should be given to the health and safety issues that may arise in the course of these activities.

In all cases, reference should be made to the overall syllabus aims and objectives which are given expression through the learning outcomes associated with the various topics and sub-topics in each of the three syllabus sections. For some learning outcomes, the student is required simply to recall the stated factual information. For others, the student should be able to demonstrate an understanding of the stated scientific facts, principles or concepts and, where required, to link or apply these or to explain their effects. Additional information on how the different types of learning experiences are addressed in the assessment arrangements may be found in section 6 of these guidelines.

Teaching strategies

Given the structure and format of the revised syllabus, teaching strategies may be considered in three broad categories: separate sciences, co-ordinated science, and integrated science.

(a) Separate sciences

In this approach, each discipline—biology, chemistry and physics—is treated as a separate entity, complete in itself, with little or no cross-reference.

(b) Co-ordinated science

In a co-ordinated science approach, while the three disciplines may be taught as separate units, the links or common concepts between them are emphasised. For example, the application of science process skills, of being ‘scientific’, is common to each discipline.

Some co-ordinated science courses are designed on the basis of modules or units of study that incorporate and illustrate the common concepts more clearly, while each element of the module remains identifiable as biology, chemistry or physics. Thus, for example, in relation to heat energy, respiration in the body involves the conversion of chemical energy in food to heat energy; in the evaporation of moisture from the skin, the latent heat involved enables the body to maintain a stable temperature.

(c) Integrated science

Integrated science aims at providing an overall, general view of science where the unifying concepts and inter-relationships of different disciplines can be stressed. Less emphasis is placed on the separateness or individuality of the different disciplines.

Planning for teaching science

There is no one or ideal way of teaching science. While the skills and processes of science are an essential part of the teaching of science, they will succeed only as part of an overall teaching strategy. Good teaching demands a combination of a wide variety of methods. The syllabus emphasises an investigative approach to science, which is aimed at facilitating students in the development of skills, knowledge, understanding and attitudes that are appropriate in a society increasingly influenced by science and technology.

Where a subject department exists in the school this is a most useful forum to discuss the organisational and development needs for science in the school. The collaboration with colleagues in the formulation of the subject policy as part of the School Development Plan is an opportunity to develop a shared understanding of science teaching in the school. It provides the opportunity to develop policy regarding teaching methodologies, school assessment strategies and the acquisition and sharing of resources.

In this context, some important features that should inform planning for teaching and learning of the revised syllabus include the following:

- The course should be taught with conscious reference to the overall aims of the Junior Certificate programme (see the inside front cover of the syllabus). Numerous opportunities exist for linkages to other areas of learning and to the everyday lives of students. These should be exploited through careful planning and evaluation of the teaching strategies to be adopted.

- Planning of the teaching and learning should be informed by reference to the general aims and objectives of the syllabus.
- Teaching practice should highlight the economic, social and cultural implications of the increased use and influence of science and technology in our everyday lives (STS).
- It is important that issues relating to the environment be treated in a way that emphasises the need to conserve and protect the natural environment while, at the same time, recognising the—sometimes conflicting—demands of economic development and activity.
- Through their enjoyment of the study of science in the junior cycle, students should be encouraged to extend this study into the senior cycle, thus opening up opportunities for further study or careers in science in later life.

Scientific enquiry links direct practical experience with key scientific concepts. Scientific enquiry should not be confined to practical classes, but should be integrated into every science class, even those that do not involve practical work. In this way, students are encouraged to think scientifically, thus developing the ability to solve problems in a logical and ordered manner.

The process of investigation helps students to understand how scientific ideas are developed. It provides students with opportunities to use and apply their knowledge and understanding while solving a problem. Teachers may use a variety of approaches to practical activity that will enable students to work scientifically.

Students should learn to

- use scientific knowledge to turn ideas into a form that can be investigated and to plan accordingly
- decide the extent and range of data to be collected and the techniques, equipment and materials to be used
- consider factors that need to be taken into account when collecting evidence
- make observations and measurements, including the use of datalogging where appropriate
- critically consider, evaluate and interpret their own data and data derived from other sources
- organise and present information clearly and logically, using appropriate scientific terms and conventions, and using ICT where appropriate.

Throughout the syllabus, the topics and sub-topics are accompanied by learning outcomes that reflect the increased emphasis on an investigative approach to science, involve a more practical approach to teaching and learning, and thus make science more relevant and interesting for students. In changing the emphasis to discovery through investigation, many of the objectives of the revised syllabus (cf. syllabus pages 4 and 5) are achieved. Examples of the change in emphasis for a number of topics are outlined in the following pages. In each case, selected syllabus objectives are cited and elaborated on in the context of the specific investigation or experiment.

Examples of changed emphasis

(a) Density

1989 syllabus – ref 2.6	Revised syllabus – OP2, OP3
Definition of density Density as a characteristic property Determination of density of a solid of a particular substance Determination of density of a liquid Flotation – related to density (no treatment of Archimedes' principle)	**measure mass and volume of a variety of solids and liquids and hence determine their densities** investigate flotation for a variety of solids and liquids in water and other liquids, and relate the results of this investigation to their densities

Rather than starting with a learned definition of density, students are encouraged to find the mass and volume of a variety of different solids and liquids. They will notice that the relationship between mass and volume of different substances is not the same in each case; in other words, there must be some other property of the material that contributes to the mass. This approach will facilitate their understanding of the concept of density in a much more meaningful way that would be the case with rote learning of the definition.

Observation, measurement and the accurate recording of data

Students can examine different objects and by direct observation notice that even when their size is similar their masses are different.
They can verify this by recording the mass and volume of objects. Many students may work out a way of determining the extent to which one object differs from another by finding the ratio between mass and volume.

The scientific method and the concept of a valid experiment

Given a variety of liquids and solids of varying densities, students can plan how they want to investigate the flotation of these solids in the given liquids.
They may want to float the same solid in all the liquids; it will float in some but not in others. They will need to plan how to use each of the solids and liquids to determine the densities of both the solids and the liquids relative to each other.

Formation of opinions and judgements based on evidence and experiment

Having obtained the information from their investigation, students can classify the materials based on their densities relative to each other. They can then verify their results by finding the mass and volume of each of the solids and liquids, and calculating their densities.

(b) Classification of organisms

1989 syllabus – ref 9.1, 10.1	Revised syllabus – OB38 OB39
There is a variety of types of animals. These are grouped into families. They exhibit the characteristics of all living organisms and as such should be respected. There is a wide variety of types of plants. They exhibit the characteristics of all living organisms and as such should be respected.	understand how to use a simple key to identify plants and animals, including vertebrates and invertebrates **investigate the variety of living things by direct observation of animals and plants in their environment; classify living organisms as plants or animals, and animals as vertebrates or invertebrates**

Students learn about the classification of living organisms based on the factors which identify them. Before looking at living things, students learn how to use a simple key.
Use of the key will require them to make observations, and then to make judgements based on those observations.

Promote logical patterns of thought
The use of the key will develop their powers of inductive reasoning. They will only proceed to the next step in the key if their reasoning is correct.

Encourage accurate observation and careful recording
Accurate use of the key will require skills of observation and recording. Students may wish to draw the organism for later identification at home or in the classroom.

Make biological, chemical and physical phenomena more real through actual experience
Keys for identification of organisms are a basic tool of the biologist, so students are learning a valuable skill. This investigation takes the student out of the text book environment and into the real environment.

(c) Activity series

1989 syllabus – ref. 8.5	Revised syllabus – OC52
List of metals in order of reactivity K, Na, Ca, Mg, Zn, Fe, Cu, Ag	<u>Investigate the relative reactivity of Ca, Mg, Zn and Cu based on their reactions with water and acid</u>

In changing the emphasis from knowledge of a learned list to discovery through investigation, many of the objectives of the revised syllabus (cf. pages 4 and 5) are achieved.

The scientific method and the concept of a valid experiment
Students will need to plan how they intend to observe the reactions of the metals with water and acid. In considering the concept of a fair test, students might take into account factors such as particle size, temperature, and concentration of acid, to ensure that conditions are the same for each metal.

Observation, measurement and the accurate recording of data
Students need to observe the reactions carefully and record their observations accurately. They may devise some form of coding for these observations, for example, quantity of gas produced or amount of fizzing, and record these in graphic or tabular form.

Logical thinking, inductive and deductive reasoning
Students might try the reaction with water first and record their observations. They could then reason that the metals that did not react with water should be tried with acid.

Formation of opinions and judgements based on evidence and experiment
Based on prior learning (OC51: reaction between Zn and HCl) and experimental evidence, students will deduce the order of reactivity.

Using the syllabus in lesson planning

The following exemplars illustrate how specific learning outcomes could be addressed in the teaching and learning of the selected syllabus topics and sub-topics, while keeping in mind stated syllabus objectives. They also indicate how learning outcomes in different sections of the syllabus can be linked and provide suggestions for assessment and for relating the learning in the selected topic to other areas of student learning.

Exemplar 1 – Topic 1A5: Circulatory system [Syllabus, pages 10 and 11]

The charts below are a useful way to capture the sub-topics and learning outcomes that fall under this main topic.

Sub-topic 1
Composition and function of blood

OB13 … know that blood contains white blood cells, red blood cells and platelets in a liquid called plasma

Sub-topic 2
Structure and function of the heart

OB14… identify the four chambers of the heart, and explain the difference between the left and right ventricles

Sub-topic 3
Passage of blood through the heart and main organs

OB15… heart and lungs via arteries and veins, identify the pulmonary artery and vein, aorta, vena cava, and distinguish between arteries, veins and capillaries

Sub-topic 4
Factors affecting human pulse rate

OB16 demonstrate the effect of exercise and rest on pulse and breathing rate; understand that a balance of each promotes good health

OB17 … the average pulse rate for an adult at rest is 70 b.p.m.; explain why exercise results in increased pulse and breathing rates

Linked learning outcomes

OB18… the normal temperature of the human body is 37 ºC; illness may cause a change in body temperature

OB19… the products of digestion are absorbed into the bloodstream and are thus circulated around the body

When planning lessons for this main topic, associated learning outcomes should be taken into account. These outcomes form the specific target or goal of learning, with the more general syllabus aims and objectives providing a broader framework. While the majority of the learning outcomes in this topic have a knowledge or understanding focus, they can be achieved through an inquiry approach that begins with the students' current knowledge and understanding of blood, its composition and its transport and defence functions.

A useful starting point might be the compilation of a brief list of prior learning which can be associated with this topic, or which leads naturally into it. Non-school experiences could be referred to, such as a visit to the doctor or hospital, or topical issues from the news, films, TV, etc. which can be the basis for an STS approach to this topic. Opportunities could also be taken to link this topic to other areas of learning, such as physical education, home economics, sport, etc.

Some ideas for this main topic are given in Section 5 (see page 31). These can be developed into more detailed 'advance organisers' as illustrated below.

Sub-topic 1

This could be approached through a brainstorming exercise to find out what the students currently know about blood and its transport and defence functions. Secondary sources, such as newspaper or magazine articles, CDs / encyclopaedias on the human body, internet searches, etc. can act as useful sources for finding information. A degree of evaluation of sources may be required before a summary of points is arrived at.

Another starting point could be information already learnt about digestion and its role in providing energy for the body, particularly if links were mentioned in previous lessons or assignments. How does the energy get around the body? What happens when the energy is converted (used)? What happens to the products of the energy conversion?

Sub-topic 2

A physical model of the heart, or a pictorial representation, could be used to familiarise students with its structure and the location of the chambers; electronic media can simulate the functioning of each chamber. The attention of students can be drawn to the physical difference between the left and right ventricles of the heart, with initial discussion of possible reasons for the difference. This can be reinforced later when treating of the difference between arteries and veins.

Sub-topic 3

A 'circuit' approach is one that can help the student understand the circulation of blood around the body, as it passes through the various main organs. If appropriate, the analogy of the school's (or home) central heating system can be used. Specific attention should be paid to the heart itself and to the lungs, with explicit mention of arteries and veins (drawing distinction between these), <u>with particular reference to the pulmonary artery and vein, the aorta and vena cava (HL only).</u> In terms of the circulation of the blood and its function in distributing energy around the body, this could be introduced by means of a storyline from the perspective of glucose and oxygen making their way to a muscle cell (cf. 1A4, OB9).

Sub-topic 4

The main focus in this sub-topic and the associated learning outcomes is on the active investigation. Students should be encouraged to apply the same planning skills to this as to other (mandatory) investigations. Thus, they need to consider what factors they wish to investigate, what are the variables, what they will keep constant, what they intend to measure (and how), how they can ensure a fair test, etc. Do they know how to measure pulse? How much exercise will be required to show measurable difference in pulse and breathing rate? What other factor(s) may be contributing to a change in either pulse or breathing rate?

As is usual for such activities, a teacher's checklist of the resources required, teacher inputs, safety considerations, etc. will prove useful. Although this is not a mandatory activity, students should be encouraged to record the key points and data, which will be useful as a revision aid at a later stage.

Additional learning outcomes

These can be introduced as appropriate in the sub-topics above, or dealt with after the sub-topics have been addressed. They could be reserved for a time when this main topic is being revised and/or also serve as useful points of linkage between this topic and others such as digestion, respiration, energy conversion, and heat.

If appropriate, attention may be drawn to issues such as cardiovascular disease, its effects on the circulatory system, and what steps can be taken to avoid it.

Assessment of student learning

When the set of lessons on this topic is complete, a variety of assessment methods may be used to determine the extent to which students have attained the required learning outcomes: class discussion, knowledge tests or quizzes, word mazes, presentation of findings or of additional search results, demonstration using electronic or physical media, production (individually or in groups) of illustrated diagrams showing the structure of the heart or the circulatory system, etc. Can the students measure their own pulse rate, or that of another student? Is it greater/less than the average of 70 b.p.m.? What might be a reason for this? Can students show that a short period of exercise results in a changed pulse rate?

Students may be interested in undertaking a Coursework B investigation related to this topic.

Linking forward and outward

It is useful, when finishing with a topic, to map out where it may arise again in relation to other topics, to note (from the assessment) whether all sub-topics have been understood or may need to be re-visited at a later time, and whether (and how) it is intended to include aspects of this in future assessments or tests.

Finally, opportunities should be availed of to link learning in this topic to other areas of learning, including biology at senior cycle where students can expect to study in greater detail about the heart and the circulatory system.

Exemplar 2 – Topic 2A7: Water and solutions [Syllabus, pages 18 and 19]

The charts below are a useful way to capture the sub-topics and learning outcomes that fall under this main topic.

Sub-topic 1
Water as a solvent

OC 15 Investigate the solubility of a variety of substances in water

OC 16 Examine the difference between a dilute, concentrated and saturated solution

Sub-topic 2
The effect of temperature on solubility

OC15 Investigate … the effect of temperature on solubility

Sub-topic 3
Formation of crystals

OC17 **Grow crystals using alum or copper sulfate [mandatory]**

Linked learning outcomes

OC2 Separate mixtures using a variety of techniques: filtration, evaporation, distillation and paper chromatography

OC14 Use cobalt chloride paper or anhydrous copper sulfate to test for water

OC30 **Conduct a qualitative experiment to detect the presence of dissolved solids in water samples, and test water for hardness (soap test) [mandatory]**

OC31 Understand that some dissolved compounds including compounds of calcium cause hardness in water

OC44 Investigate the ability of ionic and covalent substances to conduct electricity

When planning lessons for this main topic, associated learning outcomes should be taken into account. These outcomes form the specific target or goal of learning, with the more general syllabus aims and objectives providing a broader framework. The majority of the learning outcomes in this topic require some sort of investigation and can be achieved through an inquiry approach that begins with the students' current knowledge and understanding.

A useful starting point may be the compilation of a brief list of prior learning which can be associated with this topic, or which leads naturally into it. Students will be familiar with solutions and dissolving from everyday life. They should be able to predict what effect temperature will have on the rate of dissolving, based on day to day activity or experience.

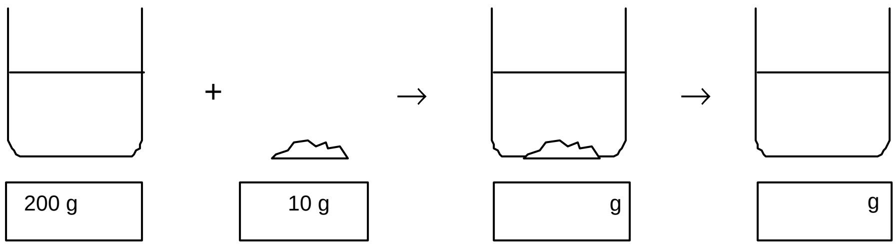
They may have grown crystals at primary school without understanding the scientific concepts involved. Opportunities should also be taken to link this topic to other areas of learning, such as home economics, geography, etc.

Some ideas for this main topic are given in Section 5 (see page 41). These can be developed into more detailed 'advance organisers' as illustrated below.

Sub-topic 1
Students should already be familiar with the idea that substances dissolve to form solutions. Reference should be made to OC2 (separating mixtures). From information they already have, students can predict which of a number of substances will dissolve in water.

This exercise can be extended to include more probing questions about mass and dissolving. For example:

Some water was placed in a beaker, and its mass was measured using a balance. The mass of beaker and water was 200 g. Then 10 g of sugar was weighed out. The sugar was added to the water, and sank to the bottom. 10 minutes later the sugar could not be seen.



a) *Fill in the boxes to show what you think the mass of the beaker and its contents would be when the sugar was first added, and then after it could no longer be seen.*

b) *Where did the sugar go? Explain your answer (source www.chemsoc.org).*

A simple exercise like this can be used as a diagnostic tool to show exactly what students understand by 'dissolving'. It can also be used as a prelude to classroom discussion. Common misconceptions about dissolving include

- the sugar 'disappears'
- the sugar melts.

Students' understanding should be probed so that these misconceptions, if they exist, can be rectified.

The idea of concentrated and dilute solutions is likely to be familiar to students from 'strong' or 'weak' diluted drinks. They know that the more sugar that is put in tea, the sweeter it gets. Ask students to design an investigation to see whether there is a limit to the amount of a substance that will dissolve in water at a given temperature. Different groups of students could use different volumes of water or different amounts of the substance; the results can be drawn together and patterns identified and discussed. (A useful simulation of this investigation can be found at www.juniorscience.ie under 2A7 resources.)

Sub-topic 2
Use a familiar concept such as dissolving jelly, tablets, etc. to encourage students to predict what effect changing temperature might have on solubility. Students may also extend this to discuss what other factors might affect the rate at which the substance dissolves.

Having discussed this topic, students should plan and carry out a valid investigation of the effect of temperature on the solubility of a salt or sugar in water. Students should account for variables.

Reference could be made here to gases dissolved in water and, for example, the effect of temperature on the availability of oxygen for fish.

Sub-topic 3
Students may be familiar with the crystallisation that sometimes happens with honey or home-made jam. Following on from sub-topic 2, students should be familiar with the concept of saturated solutions. They should also be aware of what happens to solutions as they cool.

Growing the crystals is an enjoyable activity. It allows learning outcomes about water and solutions to be revisited. Students can be asked for scientific reasons for some of the procedures involved.

Additional learning outcomes
These can be introduced as appropriate in the sub-topics above, or dealt with after the sub-topics have been addressed. They could be reserved for a time when this main topic is being revised and/or also serve as useful points of linkage between this topic and others such as separating techniques, ionic and covalent substances, hardness of water, plant transport and circulation.

Assessment of student learning
When the set of lessons on this topic is complete, a variety of assessment methods may be used to determine the extent to which students have attained the required learning outcomes: class discussion, knowledge tests or quizzes, presentation of findings or of additional search results, interpretation of graphs and/or data, discussion of results of investigations, etc. Can the student grow a crystal? Can he/she give everyday examples of dilute or concentrated solutions, or where the effect of temperature change on solubility is taken into consideration?

Students may be interested in undertaking a Coursework B investigation related to this topic, such as investigating water in their local environment.

Linking forward and outward
It is useful, when finishing with a topic, to map out where it may arise again in relation to other topics, to note (from the assessment) whether all sub-topics have been understood or may need to be re-visited at a later time, and whether (and how) it is intended to include aspects of this in future assessments/tests.

Finally, opportunities should be availed of to link learning in this topic to other areas of learning, including chemistry at senior cycle where students can expect to learn in greater detail about solubility, types of solvents and solutes, and rates of reaction.

Exemplar 3 – Topic 3A7: Energy conversion [Syllabus, pages 26 and 27]

The charts below are a useful way to capture the sub-topics and learning outcomes that fall under this main topic. Note that some learning outcomes associated with section 3C are linked to this topic and it may be desirable to deal with these first.

Sub-topic 1

Energy conversions

OP20 identify different forms of energy and carry out simple experiments to show the following energy conversions:

a. chemical energy to electrical energy to heat energy
b. electrical energy to magnetic energy to kinetic energy
c. light energy to electrical energy to kinetic energy

Sub-topic 2

Examples of energy conversion from everyday experience

OP21 give examples of energy conversion from everyday experience

Linked learning outcomes

OP17… the principle of conservation of energy

OP51 demonstrate simple … circuits

OP53 describe the heating effect, the chemical effect, and the magnetic effect of an electric current, and identify everyday applications

OP57…a light emitting diode (LED) requires less current than a bulb

While the general syllabus aims and objectives (syllabus page 4) provide a broad framework or backdrop, a particular knowledge and understanding objective comes into sharp focus in this topic:

The student will develop a knowledge and understanding of… energy in its various forms, the application of energy conversions, and the need for economical use of energy sources.

In addition, students are expected to be able to apply scientific knowledge to everyday life experiences. The topic of energy conversion affords a variety of possibilities to adopt an STS approach, such as consideration of the ways and means by which we obtain and use energy, the problems (and some of their solutions) in relation to energy availability and supply in third world countries, etc.

Some ideas for this main topic are given in Section 5 (see page 48). The following examples illustrate how the sub-topics might be developed. It is likely that some of the 'everyday examples' (in sub-topic 2) will arise naturally in the course of the discussion and activities associated with sub-topic 1.

Sub-topic 1
The students' present knowledge of energy can be explored through a brainstorming exercise, which is also a useful way to categorise the various forms of energy using the student's examples. There are immediate links here to other syllabus topics and learning outcomes, such as respiration (1A4), converting chemical energy in food to heat energy (OB5), and the topic of energy itself (3A6).

In considering energy sources (cf. 3A6), an electric cell or battery can form the basis of discussion of the type of energy (chemical) that is 'stored' and the type of energy that is 'released' (electrical) when the battery is being 'used'. It can help the student to get a more complete understanding of energy if the 'charging' of a (re-chargeable) battery is cited as an example of electrical energy being stored as chemical energy in the battery for later conversion or use. Students interested in the International Space Station (ISS) could check out the information available on its website regarding the need to store energy for use during that part of the orbit (about 30 minutes) when the ISS is in darkness.

Another point of reference is the activities under OP50 and OP51 (if these precede topic 3A7) in which different devices or components in a circuit can be referred to as 'energy converters'. It is useful if students can recall these circuits and discuss what energy conversion(s) may be taking place in the components. [Alternatively, where sub-topic 3C4 arises after 3A7, backward reference can be made to energy conversion when those circuits are being investigated.]

Conversion (a) – chemical energy to electrical energy to heat energy
A very simple illustration of this type of energy conversion is a basic electric circuit containing an electric cell or battery and a (filament) bulb. To keep the focus on these two components, the battery connector can act as the circuit switch. When current flows in the circuit, the chemical energy in the battery is converted to electrical energy in the circuit. The bulb acts as an energy converter, producing both light and heat. A thermometer may be used to show a rise in temperature at the bulb's surface.

With an eye on learning outcome OP57, reference could be made to the difference between a filament bulb and a LED in such a circuit.

Everyday examples of this energy conversion include the battery torch and the spark plug in a car (or lawnmower) engine; some diesel engines use a heater coil to aid ignition. This conversion sequence could also be discussed in the context of Luigi Galvani's discovery of the effect of two joined metals coming into contact with different parts of a frog's leg, producing movement.

Some students might be interested in researching information on fuel cells. Perhaps students could be encouraged to make a 'fruit battery'.

Conversion (b) – electrical energy to magnetic energy to kinetic energy
A few possibilities arise here. While an electric motor is an obvious choice, with discussion to point out what conversions are taking place, it is not always clear to the student what is happening. A battery or power supply can be connected to a simple motor, producing rotation (movement). A more 'visual' engagement with what is taking place can be managed if an electromagnetic coil is placed over or near a number of pins (or a magnetic compass). When the electromagnet is 'switched on' (i.e. electric current flows through it), the pins will be

attracted to the coil (or the compass needle deflected). The movement (kinetic) is brought about by conversion of the electrical energy in the coil to magnetic energy, which gives rise to the movement.

A similarly illustrative example can be set up if a bar magnet is placed partly inside an electromagnetic coil. When the coil is 'energised', the magnet will move either further into or out of the coil (depending on the polarity of the electromagnet). This can be linked to discussion of magnetism.

Everyday examples of this energy conversion include the electric motor (motorised toys are a good illustration), the traditional electric bell, a battery-operated clock, the 'relay' switch (perhaps familiar to students doing technology projects), and the circuit breaker in domestic electric circuits. The ESB meter is another everyday example of this conversion.

Conversion (c) – light energy to electrical energy to kinetic energy
In the previous energy conversion, a battery could have acted as the source of the electrical energy. However, light is also a form of energy (refer to OP33 and 3A6) and a solar cell can provide a small amount of electrical energy. When used in conjunction with a 'solar motor' (one that operates with very low currents), the required conversion sequence can be illustrated.

Large (arrays of) solar panels on the International Space Station are used to provide the energy required for the electric motors that control the gyroscope system.

Sub-topic 2
As indicated earlier, examples will arise in the course of sub-topic 1. However, sub-topic 2 is not restricted to the three 'double' conversions covered in sub-topic 1. Thus, students should be encouraged to propose and list examples of 'single' conversions from a variety of energy forms.

Linked learning outcomes
These links can act either way, depending on the sequence of topics adopted in class. In as far as possible, appropriate links and cross-references should be made when the sub-topics arise, or when they would help to reinforce the students' knowledge and understanding.

Assessment of student learning
When the set of lessons on this topic is complete, a variety of assessment methods may be used to determine the extent to which students have attained the required learning outcomes: class discussion, knowledge tests or quizzes, presentation of findings or of additional (re)search results, demonstration using electronic or physical media, production or display (individually or in groups) of illustrations or mini-projects on related themes. Can students discuss the advantages or disadvantages of different energy conversion processes?

Students may be interested in undertaking a Coursework B investigation related to, or arising from, energy conversions.

Linking forward and outward
This topic can be related to a number of other science topics, as already indicated. It can also be linked to other areas of learning such as environmental issues, renewable energy, conservation, geography, history, and the technology subjects.

Using ICT in the teaching and learning of science

Information and communication technologies (ICTs) can enhance the teaching and learning of science. A vast amount of information is available on CD-ROMs and on the World Wide Web. Specific applications can be used to provide animated images of objects and events, making these more real for students. Exploratory and interactive software can provide opportunities to

- observe phenomena that are not usually visible (such as a journey into the human body)
- control processes (such as chemical reactions) that are not normally easily controllable
- participate in learning activities that might otherwise be impractical or dangerous (such as exploring the effect on a fuse of an overloaded electric circuit)
- make decisions and observe the consequences of these
- test hypotheses and formulate actions in a safe environment
- work collaboratively for a common goal.

Teachers may use ICT to complement classroom or laboratory activities, to prepare and present classroom learning materials, to research additional information or references, to communicate with their peers and share ideas, and to keep and update class tests, student records, etc. Students can use ICT for self-directed learning, to explore new concepts that arise in the course of their learning, and to reinforce the understanding of concepts and processes already encountered.

In using ICT in the teaching and learning of science, care should be taken not to simply replicate a traditional teaching approach using a modern tool, but to take advantage of its potential for adding value to the learning experience. Thus, for example, datalogging provides for easy and rapid recording of data and its analysis and presentation in 'real time', thus allowing patterns and trends to be observed and monitored. In the next section, internet references are included that illustrate some of the points referred to above.

General guidelines for the use of ICT at post-primary level are currently being developed by the NCCA, and these will be complemented by subject-specific guidelines.

5. Ideas for learning activities

As well as identifying specific content in the form of topics and sub-topics, the revised syllabus contains learning outcomes in each section and sub-section which specify what it is that each student is expected to know and to be able to do as a result of his/her experience of science. Many of these learning outcomes are activity focused. In each of the three main syllabus sections, ten mandatory activities are highlighted; students are required to keep a record of these thirty practical activities. This record forms one element of the assessment (i.e. Coursework A) and accounts for up to 10% of the total examination marks.

The precise procedures for carrying out these activities are not specified, however. This facilitates a variety of approaches, depending on the circumstances prevailing in a given school or at a given time. The focus is on achieving the intended outcomes, regardless of the approach taken. Such flexibility enables the teacher to explore science in different ways, and thus match the learning experiences to the abilities and interests of the students. The assessment of science will take this changed approach into account. Students will not be required to know or describe a specific way of conducting an activity where this has not been stated in the learning outcomes. However, one of the outcomes of their learning should be an ability to comprehend and respond to questions on methods of carrying out an investigation or activity in a way other than one which was specifically done by them.

The following pages contain ideas for learning activities that could be undertaken in the teaching of the science topics described in the syllabus. These are not mandatory activities, but rather suggestions that may prove useful to teachers when planning student learning. The choice of an activity should be influenced by a range of factors: the time available, the ability range of the students, the resources required and those immediately available, considerations of health and safety, etc. A number of website addresses are included that provide appropriate alternative approaches to activities and relevant background information. At the time of printing these sites are active; however, it is important to be aware that, over time, website addresses may become outdated.

The tables are set out using the syllabus headings and codes, and should be used in conjunction with the syllabus. This should not be taken to mean that all the activities in the following pages are required; only those activities which are specified in the syllabus are examinable. Rather, the activities suggested are opportunities to enrich the students' understanding of the various concepts and to develop their range of investigative skills.

Note that, in some cases, the scientific terms used are ones that would be familiar to teachers, but not necessarily appropriate for students. Some activities are listed as extensions, and these should only be undertaken where students have already shown a firm grasp of the underlying concepts, have developed the required skills, and would find these activities of further benefit.

Some of the activities listed in the tables on the following pages may prove suitable springboards for an investigation of the student's own choice that could be undertaken as Coursework B in place of the set investigations.

The links indicated in column 2 of the tables allow individual topics to be associated with other topics or learning outcomes in the syllabus and with different curriculum areas. They also provide links to developments in business or industry, to modern applications of science and technology, to the names of prominent scientists whose work is closely associated with the particular topic and to everyday issues or events in the lives of the students. These links are points of reference and are not intended to be dealt with in depth when the learning activities are being undertaken. They are neither prescriptive nor exhaustive.

In addition to the range of activities listed here, many other ideas for student learning activities were also tried out, discussed and recommended at the in-service education courses offered by the Junior Certificate Science Support Team. The CD provided to each science teacher contains numerous learning ideas and resources that complement those listed in these guidelines.

Biology Section 1A: Human biology – food, digestion and associated body systems

Within a context of health education, students should be taught the importance of a healthy lifestyle to maintain the body systems in order to enjoy a good quality of life.

For the study of human biology it is necessary to examine models of the human body or pictures from secondary sources to identify and locate the body systems as required by the syllabus in Section 1A and 1B. The guidelines given below are in addition to the use of models and secondary sources emphasising the experiential approach of eliciting what the student is already familiar with and building on that knowledge, understanding and skill.

Possible learning approaches/activities	Links to other topics	Alternative or extension learning activities
1A1 Food Discuss energy content of food and identify some dietary problems experienced by teenagers. Identify 6 constituents of a balanced diet. Provide students, in small groups, with a variety of labels from different food products, e.g. milk carton, cheese pack, bread, crisps, chocolate, etc, and discuss lists of different food types recorded. Use a secondary source for students to identify the function of each food type. Using "amounts per 100 grams" on food labels, design and construct food pyramids based on Recommended Daily Allowance (RDA) of protein, fat and carbohydrate. Conduct qualitative food tests for starch, reducing sugar, protein and fat. Investigate heat generated by the same mass of fat, carbohydrate and protein. Consider how a fair test may be constructed. Discuss other products of the reaction and the concept of waste products.	To include an intercultural perspective use examples of foods from non European countries Construct a food pyramid using examples of food from Asia only, from Africa only, etc. Where appropriate, reference could be made to the food studies section of home economics. 3A7: energy conversions Oxidation of glucose (respiration) Oxidation of metals (rusting)	Discuss obesity and associated dramatic increase of type II diabetes in young children, with associated cardiovascular disease in later life. **http://diabetes.about.com/library/weekly/aa021901a.htm** may be used as a resource. Test some food samples to identify the presence of the main food constituents, for example a typical lunch for a student. Discuss the nutritional value of the lunch sample. Plan menus for a balanced diet
1A2 Digestion Use models to discuss the function of major parts of the digestive system: mouth, oesophagus, stomach, liver, pancreas, small intestine, large intestine, and the function of different tooth types.	Check http://www.dentalhealth.ie for up to date information on dental care.	Investigate the relationship between surface area and absorption. Use disclosing tablets to demonstrate plaque

Possible learning approaches/activities	Links to other topics	Alternative or extension learning activities
1A3 Enzymes Use a model to explain the process of digestion, e.g., visking tubing filled with a starch "meal" and amylase, include a control. Use iodine test as learnt in previous section. Use models of atoms or a linked chain to explain the breakdown of large molecules by enzymes. Identify the substrate, product and enzyme. Discuss the role of enzymes in everyday life. Use washing powder solution and milk agar plates to show how enzymes in washing powder work.	OC61: chemistry in the food industry Enzymes used in brewing Enzymes as catalysts Respiration and the need to control energy release	Design an investigation to demonstrate the effect of changing one variable (e.g., temperature, pH) on the rate of enzyme action. Design an investigation to test whether is it better to wash at 40 °C than at 60 °C when using biological washing powder.
1A4 Aerobic respiration Refer to the investigation on the conversion of chemical energy to heat energy to explain the use of oxygen in the release of energy from food. Introduce and discuss the terms respiration and aerobic respiration. Use the concept of equation to discuss word equations in science. Develop with the students the word equation for respiration. Discuss the distinction between respiration and breathing. Involve students in measuring their breathing rate under different conditions, for example at rest, after exercise, etc. Investigate the differences between carbon dioxide levels in inhaled and in exhaled air. Discuss reasons for these differences. Discuss the diffusion of gases in the air and the concept of gaseous exchange. Use models and secondary sources to show the human breathing system and the exchange of gases between the lungs and the blood stream. Discuss the harmful effects of smoking.	P.E., fitness training	Use secondary sources of data to investigate CO_2 changes over a field of crops. Relate this to photosynthesis. Investigate levels of fitness by designing simple step tests. Carry out an investigation to show how cigarette smoke affects cotton wool and discuss the effects of cigarette smoke on the lungs.

Possible learning approaches/activities	Links to other topics	Alternative or extension learning activities
1A5 Circulatory system Use secondary sources to look at the composition of the blood. Discuss the concept of the living cells in blood. Use a model to look at the chambers of the heart and to identify the location and function of each of the chambers. <u>Identify the pulmonary artery and vein, aorta and vena cava</u>; distinguish between arteries, veins and capillaries. Discuss the movement of glucose from the digestive system and oxygen from the lungs to enable the release of energy in a muscle cell. Design and conduct an investigation to demonstrate the effect of exercise and rest on pulse and breathing rate and to find out whether pulse rate depends on height, age or sex. Consider the circulatory system as a central heating system. Involve students in finding normal body temperature. Discuss the effect of illness on body temperature.	1A1: Food Breathing and respiration Evaporation causes cooling Relate body temperature to enzymes OP29: latent heat OP 31: heat transfer	Find out the effects that cardiovascular disease has on our circulatory system, and what we should do to avoid cardiovascular disease.
1A6 Excretion Discuss the waste products of the body and explore the term excretion. Name the products of excretion: CO_2, water and urea. Use models or picture charts to identify the location and function of the urinary system; the bladder, renal artery, renal vein, ureter, urethra, and kidney. Discuss the excretory function of the lungs. <u>Discuss the function of the skin in the excretion of waste products made in the body.</u>	Link with food digestion OC2: separating techniques OC16: solutions, dehydration, salt uptake, etc. OB12: gaseous exchange in the lungs	Discuss kidney dialysis and factors that affect urine output.

Section 1B: Human biology – the skeletal/muscular system, the senses and human reproduction

Movement and sensitivity are central to our existence. The bodies of animals (including humans) have parts, including the skeleton and muscular systems, which have different functions, all of which help the animal to live successfully. The senses allow us to obtain information from our environment. Continuity of life is maintained through reproduction. Genetic information is passed on to us by our parents. Human bodies change as they grow.

Possible learning approaches/activities	Links to other topics	Alternative or extension learning activities
1B1 Skeletal system Discuss the functions of the human skeleton in support, movement and protection - compare with an organism without a skeleton. Examine models of the skeleton and identify the following parts: skull, ribs, vertebrae, collarbone, shoulder blade, humerus, radius, ulna, pelvis, femur, tibia, and fibula.	OP9: levers Galen of Pergamum http://www.timelinescience.org/resource/students/blood/act1.htm OC52: calcium 1A1: food	Design and make a model forearm. Use this to investigate antagonistic muscle movement.
1B2 Muscular system Use models and secondary sources to locate joints and muscles in the body. Discuss antagonistic pairs, tendons and ligaments. Use models to understand the general structure and action of different types of joints and identify examples of each.	Relate muscle building to protein	Discuss sports injuries, for example, Achilles tendon and lateral and cruciate ligament damage in football players. Compare physical processes in plants and animals based on their needs; discuss why plants and animals have evolved various mechanisms.
1B3 Sensory system Discuss the five senses and their function. Relate light and sound to detecting information about our surroundings (emphasis on gathering information from the surroundings rather than the detail of the processes). Identify the brain and spinal cord and the sensory and motor function of the nerves. Using models, identify the parts of the eye and the function of the cornea, iris, lens, pupil, retina, optic nerve and ciliary muscle	Light and sound Energy conversions Galileo and Kepler and the invention of the telescope; history of spectacles	Many investigations can be designed to study the senses; for example, design an investigation to determine whether binocular or monocular vision is better. Investigate reflex actions.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
1B4 Reproductive system Use models and secondary sources to identify male and female reproductive systems. Discuss the function of each part. Outline the stages of the menstrual cycle (the names and functions of the hormones involved are not required). Discuss the terms fertile period, sexual intercourse, fertilisation, pregnancy and birth, growth and puberty. Discuss different forms of contraception and that some of them prevent fertilisation.	SPHE; emotional changes Home Economics Social and Health Studies Reproduction in the flowering plant	Outline main similarities between animal and plant reproduction and discuss reasons for differences. View and read suitable resource material to gather information on the main physical changes that occur during puberty in males and females.
1B5 Genetics Discuss examples of inheritable and non-inheritable characteristics. Discuss content of the human cell nucleus, chromosomes, chromosome number and genes, and that inheritable characteristics are controlled by genes. Explain that chromosomes are made of DNA and protein.	Biotechnology, use of genetically engineered micro-organisms to produce pharmaceuticals Check website http://www.iob.org for up to date publications, reports, data and teaching ideas	Discuss ethical issues such as cloning of animals and genetic modification of crops. Research and write a brief biography of Mendel. Investigate simple genetically inherited traits.

Section 1C: Animals, plants and micro-organisms

Animals and plants share many similarities which characterize them as living things. The differences between plants and animals are mainly due to their different functions. Thus, for example, a plant is mainly concerned with making food and so can remain in the same place, whereas an animal is mainly concerned with catching food or running away from predators and so needs to be mobile.

Food for all living organisms is made through the process of photosynthesis. The plant is adapted to carry out both the production of food and its subsequent storage for use by heterotrophs. At the same time, plants replenish the supply of oxygen in the atmosphere and remove carbon dioxide. Plants and animals have systems that enable them to function and survive, and to respond to their environment. Competition and interdependence occur within an ecosystem

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
1C1 Living things Introduce students to the use of keys in biology. Recognise similarities between plants and animals in terms of characteristics of living things. Distinguish between living and non-living things. Use keys to identify collected samples of living things.	Check website on plant conservation in Ireland: http://www.plant-talk.org/country/ireland.html	Establish a collection of dried flowers in the laboratory. Develop a flower bed in the school grounds.
1C2 The microscope Use a microscope to examine plant and animal cells and to draw the cell structure of nucleus, cytoplasm and in plant cell the cell wall. Indicate the position of the cell membrane. Discuss the terms cell, tissues, organs and systems. In a simple way, discuss how growth occurs from cell division.	Plant and animal systems Antony van Leeuwenhoek Eyes/ senses Lenses	Use pre-prepared slides to emphasise the variety of cells with different functions.
1C3 Plant structure Observe a variety of flowering plants; identify, stem, root, leaf, buds and flowers and discuss the function of each part. Include study of plant tissues xylem and phloem. Prepare a slide of plant tissue and sketch the cells under magnification.	Food and plants adapted to store food Food tests, e.g., starch and potato	

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
1C4 Transport in plants Investigate the movement of coloured water through stems. Design a simple investigation to show that water evaporates from the surface of a leaf by transpiration.	Evaporation, movement of particles	
1C5 Photosynthesis Design and conduct an investigation to examine plant growth under different conditions: warm/cold or light/dark. Design and conduct an investigation to show that a photosynthesising plant produces starch, referring to earlier work on qualitative test for starch. Develop with students the word equation for photosynthesis. Design and conduct an investigation using bean seeds to show geotropism and phototropism. Discuss and debate the role of green plants in the environment.	Energy conversions Energy in food Food and feeding Enzymes (amylase) Respiration	Investigate why commercial growers sometimes use red or blue light in greenhouses. Design an investigation to demonstrate the energy content of food produced by photosynthesis.
1C6 Reproduction and germination in plants Discuss the differences between sexual and asexual reproduction. Conduct an investigation using cuttings to show asexual reproduction of plants. Use flowers to locate and identify the sepals, petals, carpels and stamens. Use a suitable flower to identify the stigma, style, ovary, anther and filament. Distinguish between pollen and egg and where each is produced. Discuss where the gametes are produced. Use seed samples to discuss function of seeds and seed dispersal. Describe seed structure. Grow seeds to investigate germination. Design and conduct an investigation to show the conditions necessary for germination.	Human reproduction, gamete formation and fertilisation Digestion in animals and enzyme conversion of starch in seeds to maltose Brewing industry and biotechnology, malting	Investigate which part of the emerging embryo grows faster, discuss why this might be the case, relate back to photosynthesis. Investigate the effect of gravity on germination

Possible teaching approaches	Links to other topics	Alternative or extension learning activities
1C7 Ecology Identify a local habitat for study. Visit habitat, using appropriate instruments and simple keys to identify the distribution of named plants and animals. Discuss ways in which their environment affects living things, and how they adapt to it. Discuss availability of food in the habitat, competition and interdependence. Identify producers, decomposers and consumers in an ecosystem. Construct simple food chains and a food web and predict the effects of altering the population of a member of the chain. Investigate the impact of pollution on a local area. Identify a local site that has been improved, and identify how knowledge of ecology might have influenced those improvements. Discuss conservation and waste management.	CO_2 emissions Acid rain Use of measurement in mapping in Geography Refer to the international agreement of Agenda 21 which aims to improve the sustainability of consumption and production at regional and national level to promote social and economic development. Check for further information: www.un.org/esa/sustdev/documents/agenda21/index.htm Concept of Stewardship on the CSPE course.	Use published keys to identify a range of organisms. Use both branched and paired statement types. Decision points should be made on readily observable external features; diagrams may be a useful reference in this regard. Predict how one variable affects the distribution of an organism; design an investigation to test this prediction. Use collaborative group work to create (or adapt) a key for a local habitat. Use secondary sources to compare a contrasting habitat not in the locality. Investigate the response of animals (woodlice, snails) to factors such as light or moisture; relate these responses to survival tactics. Use secondary data to investigate the disruption of a food chain. Use computer software or data from the web to test these predictions. Identify local recycling facilities and conduct survey on their usage among the families of the class group.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
1C8 Microbiology and biotechnology Design and conduct an investigation on the presence of micro-organisms in the soil and in the air. Use secondary sources to identify products of biotechnology industries. Discuss common illnesses caused by viruses and by bacteria - three in each case.	The role of yeast enzymes in the conversion of starch to maltose and maltose to glucose for fermentation Acids, bases and indicators Check Scoilnet website for links to relevant websites: http:// www.scoilnet.ie. Historical context of antibiotics; dangers of over prescribing Energy conversions, heat	Investigate temperature changes as micro-organisms break down organic material. Discuss composting. Investigate acidity in milk as it goes 'sour'. Design and carry out an investigation to determine the optimum temperature for bacteria in milk to grow. Discuss the role of micro-organisms in breakdown of waste, in the pharmaceutical industry, in the food industry, in the brewing industry. Visit a biotechnology plant.

Chemistry Section 2A: Classification of substances

Substances can be classified using three principal categories: (i) solids, liquids or gases; (ii) elements (metals and non-metals), compounds and mixtures; (iii) acidic, neutral or basic.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2A1 Materials		
List the states of matter and the common uses of solids, liquids and gases.	Measurement of volume in Physics – OP1.	Try to depress syringes filled with solid, liquid and gas. Discuss the outcomes.
Conduct investigations to show characteristics of solids, liquids and gases - refer to volume, mass, shape, compression and effect of temperature change.	Collapsing can experiment	Ask students to use their collected data to estimate the mass of air in the room.
Pour water into containers of different shapes and describe what happens. Discuss the diffusion of gases.	0B12	
Design an experiment to show that the air has mass using balloons.		
2A2 Mixtures		
Discuss methods of separation of mixtures already known to the students. Ask students to design and construct a filter using a plastic bottle and different grades of gravel; compare quality of water before and after. Separate mixtures using a variety of techniques: filtration, evaporation, distillation and paper chromatography.	Salters chemistry 2C5: hydrocarbons; fractional distillation of crude oil Filtration in the kidney Water purification	Quantitatively compare the amount of suspended solids before and after filtration.
Given various mixtures find a way of getting back the original constituents based on scientific knowledge. Ask students to offer scientific explanations for their methods.		

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2A3 Classification of subs tances, elements and compounds Discuss the Periodic Table and the list of element – identify the division into metals and non-metals. Use models to establish the idea of elements combining to make a compound. Use the example of sodium, a highly reactive metal, and chlorine, a poisonous gas, combining to make table salt. Establish the link between order of elements and proton numbers, and group numbers and outer shell electrons.	http://www.uky.edu/Projects/Chemcomics/ is a resource of comic strips, based on elements in the Periodic Table.	Research websites on the Irish scientist Robert Boyle, who is credited with the definition of an element. Compile a brief history of the development of the Periodic Table. (Include reference to the gaps Mendeleev left for unknown elements, whose existence he predicted based on scientific deduction and reasoning.)
2A4 Metals Sort samples of materials used in everyday activities into metallic and non-metallic elements. Describe the appearance of each; discuss terms such as lustrous, malleable, and ductile. Ask students to search for data on two metal elements and two non-metal elements. Record symbol, appearance at 20 ^{0}C and properties such as magnetism, conductivity, malleability. Examine samples of solder, steel, brass and bronze and discuss their use. Introduce the term alloy. Investigate transfer of heat in metals and compare to non-metals. Use a simple circuit to test electrical conductivity. Use the evidence to make a statement about conduction of heat and electricity in metals and in non-metals.	3B1, 3B2: heat, heat transfer 3C4: electric circuits	Investigate the difference in properties of alloys and the metals they come from. Carry out research into some of the uses of metals.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2A5 Non-metals Where possible examine samples of carbon, sulfur, oxygen, hydrogen, nitrogen. Describe the appearance of each and locate each on the Periodic Table. Discuss the location of metals and non-metals on the Periodic Table.	States of matter, boiling and melting	Use secondary data to compare boiling points of metals and non-metals.
2A6 Mixtures and compounds Make a mixture of sand, water and cement. Examine the constituent materials and compare them to the end product. Investigate the production of MgO and FeS; compare the properties of each with their constituent elements. Discuss the propertie s of the compounds CO_2, and H_2O and compare to the properties of the constituent elements.	Uses of concrete	Investigate the best proportions of sand water and cement required to make a hard concrete brick that does not crumble.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2A7 Water and solutions Investigate the solubility of a number of substances, sugar, salt, flour, chalk, uncooked rice, washing powder, copper sulphate, etc. Compile list of soluble and insoluble substances. Discuss the terms solute and solvent, and the use of water as a solvent. Design an investigation to find out if there is a limit to how much solute will dissolve. Identify the difference between dilute, concentrated and saturated solutions. Grow crystals using alum or copper sulphate. Design an investigation to find out what might make a solid dissolve faster; for example, size of particles, stirring, temperature of solvent, volume of solvent. Do any of the above variables alter that limit? Demonstrate how cobalt chloride paper can be used in the laboratory to test for the presence of water in a given substance.	OC42, OC43: ionic and covalent bonding www.sep.org.uk/dissolving.htm http://www.sc1.ac.uk/discover/2003ex20.cfm	Use scientific knowledge to explain why this works better at higher temperatures. What types of substance dissolve and what types do not. Is there a link to the constituent elements?
2A8 Acids and bases Investigate the behaviour of acids and bases. Use well plates or acetate sheets with small amounts of common household substances and add universal indicator. Which are acids and which are bases? Draw your own pH chart using everyday substances.	Salters chemistry club pupils worksheet 8: rainbow reaction OC28: tests on carbon dioxide gas OC37: titration More advanced: worksheet 2 chemical magic	

Section 2B: Air, oxygen, carbon dioxide and water

Air, oxygen and carbon dioxide are important chemicals in our everyday lives. Knowledge of their properties helps us to develop an understanding of the role they play. Acids and bases are present in many everyday materials and common household substances, and salts are produced when acids and bases react.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2B1 Air and oxygen Discuss the composition of air (nitrogen as the major constituent, oxygen, carbon dioxide, water vapour and other gases); approximate percentages are for higher level only. Place a piece of moist wire wool in an upturned test-tube in a well of water and leave for a few days. Discuss the results. Investigate the time taken for a candle to go out in closed containers of different volumes. Investigate burning. What else (apart from energy) is released when an organic compound burns? Compare these products to those from photosynthesis. Test the liquid product with cobalt chloride paper and the gas with moist litmus paper. Burn a metal (magnesium) in oxygen. Compare the products with those formed when the candle was burned. Develop with the students the word equation for the reaction, and the chemical equation. Introduce the term 'catalyst' (simple treatment), and test for the production of oxygen when H_2O_2 is decomposed using MnO_2. Discuss the test for oxygen and what it shows in relation to burning. Identify two uses of oxygen gas.	OC2: separation techniques Fractional distillation Argon is used in light bulbs as it does not burn Nitrogen is used extensively for fertilizers OC3: elements and compounds OB10: respiration OC14: water and solutions OC18-20: acids and bases OB48: photosynthesis OC45, OC46: rusting as an oxidation process	Discuss the use of oxygen in medicine. Having investigated the time taken for candles to go out in closed containers ask students to predict how long a candle would take to use up all the oxygen in the class room if it were airtight.
2B2 Carbon dioxide Burn carbon in oxygen and test the product using litmus paper. Prepare CO_2 and test its reaction with a lighted splint. Test CO_2 with limewater. Compare the density of CO_2 with that of air. Calculate the density of both using balloons filled with each. Is it a fair test if you blow up the air-filled balloon? Why should a pump be used?	OB48: photosynthesis OB10, OB11: respiration Carbon dioxide in fizzy drinks OC15: solutions Use of CO_2 in fire extinguishers	

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2B3 Hardness of water; water treatment Provide students with samples of hard water remains on glassware, kettles, pipes, etc. and discuss its everyday implications. Carry out a qualitative test to detect the presence of dissolved solids in water samples. Conduct the soap test on samples of hard and soft water. Discuss chemicals that cause hardness in water. Discuss ways of removing water hardness including the use of an ion-exchanger. Investigate how a sample of pure water can be obtained from salt water. Research how water treatment plants work. Make your own trickle filter to obtain clean water.	OB66: biotechnology, micro-organisms	Make an ion exchanger and compare water hardness before and after. TV adverts claim that adding a named tablet to the wash will reduce the hardness of the water; design and carry out an investigation to test this claim
2B4 Electrolysis of water Examine the term compound and identify the differences between the compound and the elements from which it is made. Conduct a demonstration to show the electrolysis of water.	Fuel cells as the emission-free engines of the future OB63: conservation, pollution	Find out about a fuel cell bus that runs on pure hydrogen – see, for example, http://www.sc1.ac.uk/discover/2003ex15.cfm
2B5 Acids and bases Discuss with the students their knowledge of the use of acids and bases in everyday activities and situations. Investigate what happens to the pH when a dilute strong acid is added drop by drop to a dilute strong base. Construct a word equation and the chemical equation for the reaction. Titrate HCl against NaOH and isolate a sample of NaCl.	OB6: digestive system; indigestion treatment with antacid Lime treatment of garden soil OB60: ecology Hair and skin care products Acid bee sting – remedy: sodium bicarbonate (a base) Alkali wasp sting – remedy: vinegar (an acid)	Investigate the differences in the acid content of a range of soft drinks. Investigate the pH of different soil types Investigate which plants grow on which soil types.

Section 2C: Atomic structure, reactions and compounds

All substances contain atoms. All atoms contain sub-atomic particles and different atoms contain different numbers of these particles. The principal sub-atomic particles are protons, neutrons and electrons. Why and how substances react can be related to their atomic structure.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2C1 Basic atomic structure Use models and secondary sources to develop the concept of the structure of the atom, the location, charge and the relative atomic mass of the subatomic particles. Define atomic number and isotopes. Discuss the location of elements on the Periodic Table on the basis of the atomic number and draw the Bohr structures of the first 20 elements.	Early work done by Dalton, Rutherford, Bohr and Stoney, which led to the model of the atom	
2C2 Bonding Use a simple circuit to test the ability of ionic and covalent substances to conduct electricity. Use the Periodic Table to predict ionic or covalent bonding. Describe the type of bonding in NaCl and MgO. Describe what a molecule is. Discuss covalent bonding in H_2, O_2, H_2O, CH_4.		
2C3 Rusting and corrosion Design and carry out an investigation to see what conditions favour rusting. Discuss examples of rust prevention.	Reactions of respiration and burning Iron as a structural material Corrosion of iron as a major problem	Try using salt water and dilute vinegar in place of water for the rusting investigation

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
2C4 Metals Discuss the common properties of Group 1 metals- appearance, storage, conductivity, ease of cutting Predict the reactions of the alkali metals with air and water. Construct the word equation for the reactions of the metals with water. Discuss Group II elements and their identification as the alkaline earth metals. Investigate the reaction between zinc and HCl and test for hydrogen. Construct the word equation and the chemical equation for the reaction. Investigate the relative reactivities of Ca, Mg, Zn, and Cu in water and in dilute acid. Use the results of this investigation to place the metals tested in order in the activity series (equations not required).		Research some aspects of current mining or aspects of the history of mining in Ireland
2C5 Hydrocarbons, acid rain Identify a number of fossil fuels. Discuss the term hydrocarbon, the elements present and predict if CO_2 and H_2O are produced when they are burned. Explore the term acid rain and how the burning of fossil fuels contributes to it. Describe the effects of acid rain (use secondary sources). Discuss the effects of acid rain on limestone and on plants. Discuss methane as a natural gas. Provide samples of plastics in everyday use. Identify how many of the everyday items we use derive from crude oil. Identify the properties of plastics and relate to their use: Plastics are made from chains of hydrogen and carbon; long chains are called polymers; plastics are non-biodegradeable; plastics are electrical insulators and can be treated with foaming to be heat insulators. Discuss the terms biodegradable and non-biodegradable and the impact of the latter on the environment. Identify the role of chemistry in pharmacy, medicine and in the food industry.	Discuss carbon dioxide as a pollutant OB63, OB64 OC2: crude oil as a mixture that is separated	Investigate the carbon cycle. Use secondary data to investigate how much CO_2 is being released per year and how the increase in CO_2 emissions is contributing to an enhanced greenhouse effect. Investigate the carbon cycle.

Physics Section 3A: Force and energy

Forces occur throughout nature and affect all aspects of living and working. Energy cannot be created or destroyed. It is converted from one form to another. It is in the process of these conversions that useful work is done. Natural resources need to be conserved.

Possible teaching/learning activities	Links to other topics	Alternative or extension learning activities
3A1 Measurement in science Measure length, mass, time and temperature; devise a method to measure student reaction time. Use recorded measurements to calculate derived quantities such as area, volume, density, speed, and acceleration (simple treatment). Present the data using graphs and charts. Discuss the difference between speed and velocity. Discuss the SI system.	French Revolution (1799) Gauss Mathematics	Research historical development of units and names. See, for example, http://physics.nist.gov/cuu/Units/background.html
3A2 Density and flotation Investigate if a number of objects sink or float in water (include also some liquids). Conduct an experiment to find the density of water, and of objects that float and sink in water. Find the density of a liquid that floats on water. Relate the result of the flotation of the solids and liquids to their densities.	See www.iit.edu/~smile/ph9613.html	Measure the weight of a variety of objects when suspended in air, water and other liquids; determine requirements for flotation. See http://www.iit.edu/~smile/ph9016.html
3A3 Force and moments Discuss the different types of forces as push or pull; describe and record the effect of a force on an object – for example, on a blown up balloon, on a ball in sport, etc. Use diagrams of different forces and discuss the resultant force. Discuss how forces work in pairs, for example pushing against a wall. Discuss the force of friction Discuss examples of lubrication in common use. Use spring balances to investigate the relationship between weight (in newtons) and mass (in kilograms); discuss this relationship. Discuss the effects of the force of gravity and how weight varies with location. Find the centre of gravity of a thin lamina. Discuss the design and the centre of gravity of an object, for example a bus or a vase. Investigate the principle of the lever and balance using a see-saw.	OB24, OB26: movement in the human skeleton Archimedes of Syracuse	Investigate the work of Isaac Newton in relation to forces. Relate to unit of force and gravity. Discuss the effects if everyday objects were taken to the Moon. Investigate movement of objects on surfaces using a force-meter, establish relative frictional values (coefficient of friction). Use a spring-balance to measure the force required to initially move an object on a high friction surface. Compare with force required to continue movement (inertia). Drop a ping-pong ball and a golf ball at the same time from a height of 2 metres. Confirm that objects accelerate to the ground at the same rate (beware of air resistance effects).

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3A4 Pressure Research the relationship between force and area, and do calculations of pressure. Provide stimulus discussion material of diagrams or pictures of practical applications of this principle, for example, snow shoes, stiletto heels, camels' feet, a bed of nails. Investigate pressure and depth for a variety of liquids. Compare and graph. Ascertain that air has mass. http://www.iit.edu/~smile/ph9706.html and http://www.iit.edu/~smile/physinde.html Discuss weather charts to observe variations in atmospheric pressure and relate these to weather conditions.	Link to breathing, diving OB10, OB11 Relate to lung damage from cigarette smoking Climate in geography	Work out the highest and lowest pressure students can exert on a part of their body by measuring cross-sectional area of various parts on which they are capable of balancing, for example, on tip-toes, hands, head, full body. Measure the diameter of an inflated balloon and calculate the volume of the balloon, assuming it has a spherical shape. Measure lung capacity using balloons
3A5 Work and power Define work – provide pictures of work and calculate the work being done in joules. Perform simple calculations based on the relationship between work and power.	Athletics – compare work/power of an athlete, horse and car over a short distance	Compare timings of volunteer runners carrying different masses over a short distance. Compare work and power of the volunteers.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3A6 Energy Melt ice or chocolate on a saucer in direct sunlight and compare with one left in the dark. Discuss the definition of energy and the unit used to measure energy – the joule. Discuss insulation and the conservation of energy in the home. Identify different forms of energy. Research different forms of energy around the classroom, e.g. sound, light, heat, wind, electrical and chemical. Discuss renewable resources. Discuss national energy needs.	Solar energy OB4, OB5: energy value of food Social geography	Discuss importance of bio-energy and how the use of biomass could reduce emissions of CO2, by about 1,000 million tones each year – a figure equivalent to the combined annual emissions of Canada and Italy. Check website: http://www.irish-energy.ie/home/index.asp
3A7 Energy conversion Investigate the conversion of energy: • from a battery to electrical energy to heat from a bulb: • from a battery to electrical energy to electromagnet to moving pins • from a solar cell to electrical energy to a motor. Collect information on the energy content of a range of foodstuffs (chemical potential energy).	http://www.iit.edu/~smile/physinde.html#p4 OB5: conversion of food energy to heat energy Check for links on http://www.scoilnet.ie	http://id.mind.net/~zona/mstm/physics/mechanics/forces/galileo/galileoInertia.html Carry out a series of simple investigations that involve energy conversion in a variety of devices, e.g., solar cell (calculator), guitar string, light-up yo-yo, wind-up torch/radio.

Section 3B: Heat, light and sound

Heat, light and sound are forms of energy that have many applications in our lives. Students should develop a basic understanding of these forms of energy and their common properties, and be able to identify everyday applications. They should be able to investigate these forms of energy, using appropriate equipment.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3B1 Heat Measure the temperature of various solids and liquids at, above, and below room temperature. Measure change in temperature for a mug of warm water over a suitable period. Explain this by referring to heat energy being lost (but take care to point out that temperature is a measure of how 'hot' something is, not the amount of 'heat energy' it contains). Determine the melting point of ice and the boiling point of water. Investigate the expansion of water on freezing. Investigate the effect of pressure on the boiling point of water. See http://astro.uchicago.edu/cara/southpole.edu/boil.html and http://astro.uchicago.edu/cara/southpole.edu/data.html#boil	Look up information on Celsius, Kelvin Mountaineering: effect of altitude on boiling point of water.	Check the following website for ideas and class materials: http://www.skoool.ie/junior.asp?id=1172 Carry out experiments that involve changes of state and record temperatures graphically. Investigate latent heat.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3B2 Heat transfer Compare conduction of heat through a variety of materials. Use a spiral of paper to demonstrate convection over a heat source. Identify and test good conductors and insulators of heat in the home. Discuss the cooling effect (loss of heat by convection) of wearing loose clothing in hot climates. http://www.nelson.com.au/physics/guide/pages/heat/heat.html?/physics/guide/pages/heat/h2.html~maintext	 Benjamin Franklin	 Investigate the loss of heat through bright and dull surfaces. Refer to clothing colours in different parts of the world.
3B3 Light Discuss ways in which light is shown to be a form of energy and how it can be converted to other forms of energy. Use metre sticks and a light source to demonstrate that light travels in straight lines. http://acept.la.asu.edu/PiN/mod/light/reflection/pattLight1.html Design and conduct an investigation to show how shadows are formed. Provide examples of luminous objects and of non-luminous objects and discuss how they differ. Design and conduct an investigation to show that light is made up of different colours. Discuss the term dispersion. List the colours of the spectrum.		 Test predictions about shadow formation on a range of materials that are opaque, transparent (plastic bottles) or translucent (greaseproof paper).

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3B4 Reflection of light; refraction of light Investigate the reflection of light by plane mirrors. Illustrate this using ray diagrams. Demonstrate and explain the operation of a simple periscope. Demonstrate that light refracts as it passes from air to glass, air to water, glass to air, water to air. Use lenses and explore what happens to a beam of light passed through a lens (refraction). Explore what happens when objects are observed through lenses. Show how a magnifying glass works.	Astronomy and Galileo	Challenge students to find out how the coloured rays produced by a prism can be remixed. http://id.mind.net/~zona/mstm/physics/light/rayOptics/rayOptics1.html
3B5 Sound Make a range of simple musical instruments (using elastic bands, rulers, drums, tuning forks, bottles) and describe the attributes in terms of pitch and volume. Show that sound is a form of energy. Explore the transmission of sound through solids, liquids and gases (including the need for a medium).	Music and musical scales	Investigate the effect of soundproofing and record sound levels in and around the school. Check http://www.scoilnet.ie for links to relevant sites.
3B6 Reflection of sound; hearing Research how a variety of animals, including humans, detect sound and make use of it. http://www.theearfound.com/anatomy.html Investigate echoes as reflected sound. Compare the speeds of sound and light over a known distance.	OB28: sense organs Refer to Michelson's experiment on speed of light	Use a signal generator and oscilloscope to establish the relationship between pitch and frequency and between loudness and amplitude.

Section 3C: Magnetism, electricity and electronics

Magnetism is a natural phenomenon with many useful applications. Electricity is a form of energy. Electricity makes a significant contribution to all aspects of our lives. Students should develop a basic knowledge of the nature of electricity, and of its supply and use in the home. They should understand the operation of simple circuits and be aware of safety issues in the use of electricity. Students are also given a simple introduction to electronics. Providing students with the opportunity to conduct investigations and experiments greatly enhances their understanding of electricity and electronics.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3C1 Magnetism Students work with a variety of magnets to test attraction and repulsion. Investigate the difference between magnetic north and geographical north. A world map aids description. http://www.sciencefinder.co.uk/magnetism.html Plot the magnetic field of a bar magnet.	Galileo of Pisa, 1564 Newton, 1642	Find out which planets in the solar system have the strongest and weakest magnetic fields. http://www.nationalgeographic.com/solarsystem/splash.html
3C2 Static electricity Examine the static electricity formed when various objects are rubbed (balloons, plastic ruler, biro, etc.) See http://www.sciencemadesimple.com/static.html#PROJECTS	Static electricity on a TV screen	
3C3 Current electricity; voltage Use a simple battery circuit with a bulb to explore conduction or insulation in a selection of household materials. Investigate what happens if the number of batteries (or bulbs) in a series circuit is altered. Test the relationship between current, potential difference (voltage) and resistance using simple circuits and meters. Show results graphically. Design and conduct investigations on the heating, chemical and magnetic effects of an electric current.	Volta Ørsted Ohm Faraday	Investigate the magnetic field strength produced by a current-carrying wire. Investigate the strength of the field by coiling wire around a suitable (iron) core, and the effect of increasing the number of turns.

Possible teaching/learning approaches	Links to other topics	Alternative or extension learning activities
3C4 Electric circuits Construct a circuit with one bulb and then find a way of adding two more bulbs without causing the brightness to dim (parallel circuits). Construct a circuit with two bulbs that can be switched on or off independently (parallel circuits). Discuss why household (mains) circuits are connected in parallel.		
3C5 Electricity in the home Use display of fuse board or circuit breakers to discuss their role in safety in the home. Discuss how to wire a plug safely - if possible provide materials for students to do so. Explore and research the power rating of electrical appliances. Discuss sample electricity bills for the home – identify the unit used by electricity supply companies. Discuss the environmental impact of the generation of electricity and the energy wasted as a consequence of the many energy transfers.	Heating effect of an electric current can cause the fuse to 'blow' Economic dependence on electricity Social/political history and geography Energy conservation	Investigate the effect of thickness of wire in electrical conductivity. Confirm that thinner wires have greater electrical resistance – consider how a fair test may be constructed Investigate the use of solar panels on houses
3C6 Electronics Explore the effect of a diode (LED) in a simple circuit. Confirm that the diode allows current to flow in one direction only. Measure the resistance of a light-dependent resistor (LDR) under varying light intensity.	Nobel winners (1956): Shockley, Brattain and Bardeen	Examine and use some simple electronic devices like alarms (smoke, burglar, water), metal detectors, light sensors, etc.

6. Assessment

Introduction

The most significant change in the revised Junior Certificate science syllabus is an increased emphasis on scientific investigation and on the application of science process skills in student activities. It is intended that the syllabus be taught through a more investigative approach – encouraging thinking, questioning, decision-making and problem-solving to develop understanding of the core scientific concepts. The assessment structure (see syllabus, page 32) is designed to assess the extent to which the syllabus aims and objectives have been achieved. It should provide a vehicle for students' responses, in both the coursework elements and the terminal examination paper, to reflect the extent to which they have developed the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions, as well as having developed science process skills associated with conducting an investigation.

Structure of the assessment

Junior Certificate science will be assessed at two levels: Higher level and Ordinary level. Marks will be allocated to the various assessment elements in the following proportions:

Coursework A – 10% (on a pro rata scale)

Coursework B – 25%

Terminal examination paper – 65%

The introduction of Coursework A and Coursework B reflects a significant change in the focus of assessment in Junior Certificate science. These coursework elements focus on the student's report of completed experimental and investigative work, based on his/her knowledge, understanding and application of the scientific method and of the concept of a valid experiment. Further, it will assess how the student has recorded data, interpreted it and communicated it.

Coursework A extends over the three years of the course, while Coursework B is conducted towards the end of the third year, by which time the students will be expected to have developed their skills in planning and conducting investigations, and in writing up their reports. (See the Appendix for sample reporting booklets.)

Separate examination papers will be set for Ordinary level (1½ hours) and Higher level (2 hours). Each examination paper will be in booklet form, with appropriate provision for candidates to enter their answers on the examination booklet itself.

Each of the three assessment elements is described in more detail in the remainder of this section.

Coursework A

Coursework A comprises the mandatory student activities specified in the syllabus, ten each from biology, chemistry and physics (these are highlighted in bold throughout the syllabus). It is envisaged that these will be completed over the course of the three years. A copy of the Coursework A checklist included in the pro forma booklet to be submitted for assessment can be used as an aid in planning these investigations and experiments and to monitor their completion.

For assessment purposes, students are required to complete reports on these activities. While it is expected that the activities will be conducted by students in small groups, ideally of two students (maximum of three), every student should complete his/her own personal record of each activity. This record, which must be available for inspection, should be in paper form and must be the individual work of the student. It can also serve as a valuable study/revision aid when preparing for the Coursework B elements of assessment and for the terminal examination paper.

Guidelines for reporting on Coursework A

The report should be neat and legible and should follow the format described below, as appropriate to the particular experiment or investigation. When the individual report has been completed the student should sign and date it, thereby attesting that he/she has carried out the activity and that the report is his/her own individual work. This date is to be recorded on the pro forma checklists submitted for assessment (see Appendix).

Content of Coursework A reports

Typically, a Coursework A report should contain the following elements, appropriate to the activity undertaken. As the student develops his/her skill of report writing, the structure of the report will gradually become better established.

Introduction

The title of the experiment or investigation should be stated clearly. The date on which it was carried out, and the name(s) of the student(s) involved should also be recorded.

Planning the activity

This could present evidence that the student has approached the activity in an organised manner, deciding what it is that should be observed or measured, which quantities are required to be kept constant and which are varied, etc.

Materials and apparatus

This includes a list of the equipment that is needed (and available), with an indication of the quantities of chemicals, etc. required. Where appropriate, a labelled diagram (or diagrams) of assembled apparatus should be included.

Procedure

This is a concise summary, in the student's own words, of the procedure that was followed in carrying out the experiment or investigation. It may include, where appropriate, safety precautions and personal protective equipment used, the nature and number of measurements or observations made, etc.

If the procedure is one of a repeated series, it will suffice to make reference to a previously described procedure, unless points of difference arise.

Data

Measurements or observations should be recorded as they are made; the data should be presented in an orderly sequence and tabulated as appropriate, with relevant units.

Calculations and graphs

This includes the main steps in the calculation and, if appropriate, reaction equations (in certain instances, word equations are sufficient). Graphs or charts, with suitable scales and labelled axes, could be used to illustrate relationships.

Results and conclusions

The final result(s) should be clearly identified, with appropriate units and to the required degree of accuracy. In qualitative work, inferences could be drawn and/or conclusions reached that are based on the observed or recorded data.

An integral part of this section should be an evaluation of the activity and its results, indicating where a different (or improved) procedure might be followed in the event of the activity being repeated on another occasion. Sources of error and the level of accuracy could be noted where appropriate; a comparison with expected or theoretical results may also be possible. An explanation should be offered for unexpected outcomes.

Assessment and Coursework A

At the end of the three years, on completion of Coursework A, each student is required to submit

- reports of the mandatory activities conducted over the three years (these are to be retained in the school)
- pro forma checklists of these activities (to be submitted together with the Coursework B reports).

Details of these requirements are given below.

(i) Reports of mandatory activities

As previously indicated, students are required to maintain records of the thirty mandatory experiments and investigations specified in the syllabus, which must be available for inspection. A maximum of 10% of the examination marks is available for completion of Coursework A. By arrangement with the school authorities, the set of reports should be submitted for retention in the school no later than the date of the terminal examination for Junior Certificate science. Failure to provide this set of reports may result in the loss of all marks associated with the assessment of this coursework element. The school should retain the set of reports and an associated checklist for the duration of the examination process, and make them available for inspection, if required.

(ii) Pro forma checklists

At the end of the three years, each student will be required to indicate, on checklists in a pro forma booklet, the number of these mandatory activities that he/she has carried out and for which he/she has completed a report. Where a student has been unable to complete all of the mandatory activities, alternative experiments or investigations listed in the syllabus—and for which a record has been maintained—may be included. This provision is limited to a maximum of two alternatives in each section.

Coursework B

Coursework B serves a dual function. It allows for assessment of the learning in science that has taken place over the previous years, that is, the extent to which the student has developed the skills necessary to conduct scientific inquiry, to think critically and logically, and to make evidence-based conclusions. At the same time, it integrates, and acts as a revision of, the knowledge and understanding that might be required when answering questions on the examination paper that are related to science investigations.

Coursework B investigations carry 25% of the marks for the examination. Each student is required to conduct two investigations selected from the three set by the State Examinations Commission or, alternatively, one investigation of his/her own choosing which represents an equivalent amount of work and which meets the requirements of the State Examinations Commission.

The inclusion of an investigation of the student's own choice as an alternative to the set investigations in the Coursework B component of the revised Junior Certificate science syllabus is designed to allow the student to carry out an investigation into a science-related topic of interest to him/her. It provides a stimulus to research an area of science, and to design, implement and report on an investigation within his/her own capabilities. It is intended to stimulate and maintain an interest and curiosity regarding science, and its relevance to everyday life. In addition to developing greater skill and understanding of science, it is hoped that by undertaking such an investigation the student will experience a sense of achievement, of pride and of personal fulfilment.

While it is important for the student to pursue an investigation that interests him/her, making a good decision with regard to the nature and type of the investigation may require guidance from the teacher. The investigation should be carried out by students individually, or in a small group (ideally two students; maximum of three per group). While much of the work can be carried out in the school during normal class time, some aspects of the investigation may need to be carried out in the student's own time, outside of school. The resources required should be those normally available to the student in the school or in their locality, and the investigation should be conducted with due consideration for safety and the environment.

Guidelines for Coursework B investigations

Investigations should be based on good scientific practice, be safe, possible to complete within the allocated time and should provide a good educational experience for the student. Therefore students should be made aware that, particularly in the case of an investigation of their own choosing, they should not embark on investigations which

(i) demand resources in excess of those normally available to them at school or in their locality
(ii) in the opinion of the teacher, are outside the stage of intellectual development and capacity of the student, i.e. topics which might be too easy or too difficult for the student concerned
(iii) are destructive to the environment or compromise the student's own safety or the safety of others
(iv) involve the use of illegal substances
(v) involve problems which cannot be solved
(vi) are trivial
(vii) are sociological in character
(viii) are based entirely on research of some part of the scientific literature and are purely descriptive in character.

Some examples will help to illustrate activities that do not, of themselves, make a piece of work scientific:

- listing the contents of a packet of soup
- the use of a balance simply to find and record the mass of a number of objects chosen at random
- the presentation of a traffic survey, which is inherently geographical, in the form of a bar-chart
- conducting a survey among a cohort of students to identify what constitutes a healthy lifestyle.

By way of contrast, the following represent valid science investigations:

- the effect of exercise on pulse and breathing rates
- the difference (if any) in mass between seedlings left in the dark for 4–5 days and similar seedlings exposed to light for the same period
- the cause of 'rising' in bread
- the factors that contribute to, or that help to prevent, rusting in iron
- the heat insulating properties of different natural and synthetic materials
- the effect on battery life of using a LED array instead of a filament bulb in a torchlight.

Stages in conducting a scientific investigation

The following steps are recommended for conducting a satisfactory investigation, whether this is one of the set investigations or one of the student's own choice. Completion of each stage contributes to the overall success of the investigation.

1. Getting started

Good planning and organisation in the initial stages of the investigation will reduce difficulties and allow the investigation to proceed smoothly. Adequate time needs to be allocated to the preliminary planning stages of exploring the work entailed in the investigation and in choosing an appropriate topic.

The following are some exploratory questions for both the teacher and the student:

- How much direction should be given?
- What techniques can be used to help students select their topics?
- What topics should be vetoed?
- How much time will be given to this work?
- When should the investigation be carried out?
- How will the field work or the lab work be organised?
- Will permission of parents/school principal be required?
- What information resources will be needed?

The time might be allocated on the basis of:

A. choosing a topic (5%)
B. student planning (20%)
C. obtaining evidence – laboratory work and fieldwork (35%)
D. analysing and considering evidence (25%)
E. evaluating and report writing (15%).

It is very important not to skimp on tasks A and B. Successful investigations require adequate planning. The time given to C and D will vary with the type of investigation. Sometimes the experimental work, analysis and writing up can be done concurrently. [It is expected that the weighting of marks between the various sections of the report will, generally, reflect the time breakdown above, but allow for differences between set and chosen investigations, and differentiation between Ordinary and Higher levels.]

2. Selecting the topic

Identifying projects as early as possible enables adequate and essential discussion between student and teacher. (E.g., how complex is the topic chosen?; can the ideas be modified and yet maintain interest?; does it suit the students ability?; is there a reasonable chance of success in the time available?)

Students in class could make suggestions of possible topics to investigate. This encourages students to think in terms of enquiring, investigating and experimenting, rather than just finding out from written sources. Some students may have definite ideas of a topic to investigate. They could be asked to write it in the form of a question to see if it is suitable. Other students may find it difficult to choose anything at all. It will be helpful for such students if the teacher can find ways to guide them towards the selection of a topic.

3. Background research

Reading in association with a practical investigation is to be encouraged. It provides students with information on which to base their study and will also help them in their statement of the problem to be investigated. Students should be encouraged to discuss their ideas with other people, to use the school and the local libraries. They should also be encouraged to communicate with relevant outside bodies (industry, e.g. ESB; food processing body; agencies, e.g. Eolas, Teagasc) when researching and making the final analysis.

4. The investigation

(i) Preparation and planning

Once a topic is chosen, this stage becomes the most important part of the student's work. If the investigation is planned well by the student, the work that follows will have relevance and an excitement for her/him. Without proper preparation the investigation will seem aimless and students will spend a lot of time seeking unnecessary help from the teacher. 'What will I do now?' becomes a common cry.

Some students may lack the ability to plan ahead effectively; it is here that guidance from the teacher can be most helpful, but it will also need to be most skilful, if the teacher is to avoid the trap of doing all of the work for the student. A worksheet to help with their planning might be worthwhile. It will be necessary for the teacher to be aware of each of the investigations being conducted within the class group. Plan the use of time carefully. Flow diagrams of organisation can help with availability of resources, equipment, etc. and can act as a form of checklist for progress. Students should maintain a logbook, keeping a record of ideas/plans, research, correspondence, gathering of evidence, results, etc. These will help in writing the final report.

The student should begin by writing the title and the aim of the investigation, which will indicate what s/he is going to explore or find out. In order to make a clear statement of the problem to be investigated students should be encouraged to pose questions that will help them to formulate a hypothesis and to identify the controls and variables as appropriate. Take for example an investigation into comparing different soil types for growing plants: a student might ask 'What type of soil grows the best plants?' 'What does "best" mean?' 'What plant is being grown?' 'At what stage is the plant tested?' 'What soil factors should be considered (e.g. particle size, pH)?' A hypothesis might be formulated such as 'Carrot plants grown in clay soil with pH 5.5–7 are tallest'. Such a statement makes a prediction and also suggests lines of enquiry for the student to follow.

(ii) Obtaining evidence (procedure, recorded data/observations)

A carefully designed method and procedure to collect the required range of data is necessary for successfully gathering evidence through laboratory work or fieldwork. This should include:

- identification of controls and variables as appropriate
- selection and use of appropriate apparatus
- careful observation
- accurate recording of data, e.g. measurement
- observation of safety procedures
- verification of results by repeating experiments.

Laboratory work will involve carrying out specific experiments or investigations to test the hypothesis stated. Fieldwork conducted outside school will often provide material for the basis of the laboratory work. Individuals and groups should check with the teacher before they start any lab work or fieldwork and present the planning worksheet for their experiments. They should specify and discuss their requirements with the teacher, and indicate how they intend to collect data or obtain evidence.

Students may have to come to terms with the fact that if they do not plan in time they will not receive what they require on the day and will have to reorganise their work for that class.

In giving approval for conducting the lab/field work, the teacher will need to consider the appropriateness of the requirements presented by the students in light of the resources available, so that all students are treated equitably. Safety is of paramount importance, and teachers should veto any experiment or activity that is considered unsafe.

Fieldwork (including surveys where appropriate) may involve work outside the school and may be done in the students' own time. Where fieldwork involves leaving school, suitable arrangements should be made re parental/school permission, safety requirements, school insurance, supervision and all related matters, as required in good classroom management. Where students have conducted fieldwork in their own time they should be asked to bring in data/observations/results to class so that they can analyse and report on them.

(iii) Calculations / data analysis

The data collected during the laboratory work and fieldwork should be presented in tables or graph format as appropriate. By studying the data the student should identify patterns and relationships.

(iv) Conclusions and evaluation

The student can draw conclusions from the findings and comment on any patterns observed. The teacher can best help students by discussing their findings with them, and prompting them with questions such as "What did you find out?"; 'Is this what you expected to happen?; "Can you think of why this might have happened?"; "Was there a pattern in the results?"; "Did it prove your hypothesis or theory?".

In evaluating the findings the student needs to consider the reliability of the data recorded and to comment on whether it is sufficient to reach the conclusions presented. The student could also comment on any weaknesses in the planning and how the investigative process could be improved. At this stage the student may also identify further investigations, which could be conducted either to support the hypothesis or to extend the scope of the investigation.

(v) Writing up the report

Students should be aware that the report must be completed in the pro forma booklet supplied by the State Examinations Commission. They should have developed their skill in writing up the report through completion of Coursework A. They should be encouraged to draw large, simple, clear diagrams, and present their results in table form as well as bar charts or line graphs, where appropriate. Mathematical skills will be of great help in ensuring that axes of graphs are drawn, numbered and labelled properly. Where students have worked jointly on an investigation they must write their reports individually.

Role of the teacher in Coursework B

The Coursework B investigation is the work of the student or students. The role of the teacher is to facilitate the student in completing each of the stages of preparing, researching, planning, gathering evidence and reporting on the investigation. This may involve the teacher in

- supporting students in the identification and choosing of topics and, where necessary, making a decision to veto investigations that are unsuitable
- regularly monitoring the progress of the investigation
- encouraging and guiding students, particularly when things go wrong
- building up a supply of laboratory equipment and reference material that would be available to the student
- setting and raising standards over the years by displaying examples of previous good investigations conducted by students.

Assessment and Coursework B

The handwritten report(s) of the Coursework B investigation(s) must be submitted in the pro forma booklet provided for this purpose (different pro forma booklets will apply for the investigations set by the State Examinations Commission and for the investigation of the student's own choice). The report(s) must be clear and legible. All stages of the work should be clearly documented and, where students have worked jointly on an investigation, each student must indicate his/her contribution to the investigation in question. As already stated, each student must write up his/her own individual report in the pro forma booklet provided.

Where a student may not have completed a syllabus investigation or experiment that could provide a basis for the Coursework B investigation(s), this could be included as part of such investigation(s).

Set investigations

Each year, the State Examinations Commission will set three investigations (one each in biology, chemistry and physics) as the Coursework B element of assessment in Junior Certificate science. These investigations, which must be school-based and conducted under the supervision of the teacher, will be based on the learning outcomes in the syllabus. Each student will be expected to select two of these for completion over 6-8 working weeks[1] in the second term of the third year, including the preparation of an associated report. The same investigations will apply to Ordinary level and Higher level candidates; differentiation between levels will be achieved by application of a differentiated standard for the two levels. This will include different weighting of the marks associated with the sections of the report, while generally reflecting the time breakdown, as noted earlier (cf. p. 59).

Investigation of the student's own choice

An investigation under Coursework B should approach an identified problem or should set out to confirm a hypothesis in a scientific manner. The investigation should be undertaken at the appropriate time during the third year of the junior cycle, when students can be

[1] The term 'working week' is used here to accommodate the mid-term break and circumstances where access to the laboratory may be on a shared basis.

expected to have developed scientific concepts and skills associated with investigations, and their communication and reporting skills through completion of Coursework A reports over the three years. In some cases, depending on the subject and nature of the chosen investigation, it may be necessary to carry out the work at a time other than that recommended for the set investigations.

The investigation should be carried out under the guidance of the teacher. As in the case of the set investigations, differentiation between Ordinary level and Higher level candidates will be achieved by application of a differentiated standard for the two levels. This will include different weighting of the marks associated with the various sections of the report, while reflecting the time breakdown, as noted earlier (cf. p. 6).

Submission of coursework

At the end of the period allocated for the completion of the coursework assessment elements, each student will be required to submit the appropriate pro forma report booklet containing

- the completed checklists indicating the mandatory syllabus experiments and investigations (Coursework A) that have been carried out and recorded in accordance with the specified criteria, and for which credit is claimed
- a report on each of two specified Coursework B assignments from among the three set by the State Examinations Commission, or one investigation of the student's own choosing, within given parameters.

The candidate will be required to sign a standard register in accordance with the procedures set down by the State Examinations Commission (refer to circular S04/06), confirming the submitted material as his/her own individual work. This register will be signed by the class teacher and the school principal, and a copy sent to the State Examinations Commission, together with the required coursework items. It will serve as a check-back where a school is visited to examine the students' reports, or where a need arises to confirm the details in the submitted pro forma booklets.

The terminal examination paper

The terminal examination paper is allocated 65% of the total marks. The paper cannot assess skills in areas specifically related to conducting investigations and experiments in the laboratory; for example, 'observation, measurement and accurate recording of data'. However, it can assess the ability of the student to

- apply the scientific process
- reproduce knowledge
- interpret data
- evaluate a scientific process
- analyse results
- draw conclusions
- relate and apply their scientific knowledge to the world around them
- problem solve
- communicate clearly their knowledge and skills

While it may not be practicable to assess all of these skills in one examination paper, a wide range of questions can provide each student with the optimum opportunity to communicate the knowledge and skills learnt in the study of science.

Differentiation between Higher level and Ordinary level

Learning outcomes that are specific to Higher level students are indicated by underlining throughout the syllabus. There will be separate examination papers for each level. At Higher level, students will be expected to show greater knowledge and understanding of the concepts and principles of science and their applications. They will be expected to handle more complex data and to demonstrate greater skills of analysis and interpretation. They should be able to respond to contexts and situations of a more complex nature, and present their findings and conclusions in a more structured manner.

Outline of the examination paper

Students are required to complete all parts of the paper using the space provided in the examination booklet. The paper is divided into three main sections – biology, chemistry and physics – reflecting the structure of the syllabus. Each section contains three different types of questions, with a marks weighting of 40:30:30.

Question 1 type – 8 short items consisting of not more than two parts. The first 6 items will be mainly recall type questions; the last 2 items in each section will be more interpretative, or analytical, or process based. Recall items may be of the completion type:

> The lungs exchange gases. Choose an answer from the following list to complete parts (i) and (ii): ***Carbon Dioxide; Nitrogen; Chlorine; Oxygen.***
>
> (i) Name a gas the lungs take from the air: ____________________________
>
> (ii) Name a gas the lungs breathe into the air: ____________________________

or require candidates to provide multi-part answers:

Complete the table for the chemicals named in the box below. The first one is already filled in.

Chemical	**Element or elements**	**Symbol**
Sodium chloride	Sodium, Chlorine	NaCl
Hydrogen		
Oxygen		
Carbon Dioxide		

They may require the student to give a definition or state a law:

> (i) What is meant by an alloy?
>
> ____
>
> ____
>
> Give two examples of alloys.
>
> Example 1 ______________________ Example 2 ______________________

Or

> (i) Which of the following substances is a base? H_2SO_4, NaOH, HCl?

____

(ii) What is an alkali?

____

They may be supported by illustrations to test recall of facts:

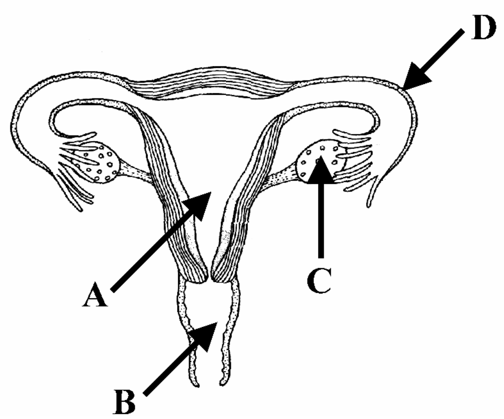
Use the labels in the diagram to identify each of the following parts of the female reproductive system.

Ovary: ___

Womb: ___

Fallopian tube: ___

Vagina: ___



They may involve calculations:

An electric light bulb has a power rating of 100 W; electricity costs 12 cent per kW h. Calculate the **cost** of having the light switched on for 5 hours every day for 10 days.

Finally, short items may require limited process description or analysis:

You are given two bar magnets, a wooden retort stand and some thread. Describe how you would show that one pole of one magnet is attracted to one pole of the other magnet (you may use a labelled diagram).

Question 2 type – This question can relate to one or more topics from the syllabus. Its purpose is to test how the student can apply their scientific knowledge to contexts and situations in the natural world. As well as testing their knowledge, this question type will assess students' skills particularly in the area of logical thinking, inductive and deductive reasoning and the formation of opinions and judgement based on evidence and experiment.

The following example of this question type shows how the student may be presented with an everyday context/situation and asked to apply his/her knowledge and skill to answer specific questions.

A family bought a 'night glow' garden light, similar to the one shown in the picture, which does not require connection to the mains electricity supply. The light has an on/off switch and a solar cell on the top which re-charges two batteries during the day. When darkness falls, the light-emitting diode (LED) comes on automatically and remains lighting for a number of hours.

(i) What energy conversion is taking place in the garden light during the day?

____

(ii) Complete the following statement by inserting appropriate words.

The garden light glows ____________________ at night during the summer

months because ____

____

(iii) Give two factors that should be considered when deciding on the best location for such garden lights?

____

____

____

(iv) Apart from the switch, batteries, LED and solar cell, what other electronic device must the night light contain in order to come on automatically?

____

(v) Name one other everyday use of solar cells.

____

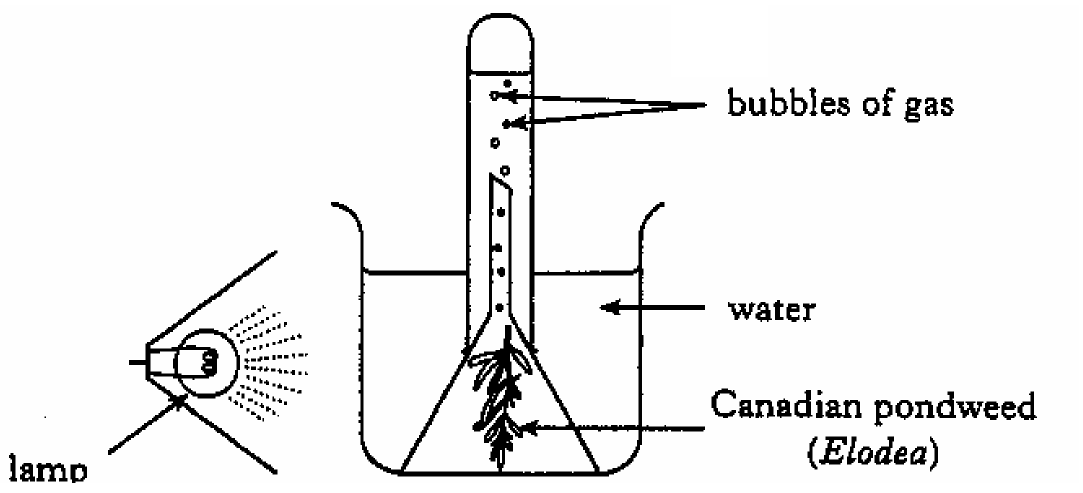
(vi) Write down two advantages of this type of light compared to a light that uses the mains supply.

(a) ____

(b) ____

Question 3 – This question can relate to one or more topics from the syllabus. It will assess the student's understanding of the scientific process, his/her skill in the development and use of procedural plans, and the use of the scientific process in problem-solving. The following example illustrates this type of question.

1. An experiment was setup to investigate the effect of light on the rate of photosynthesis.



The pondweed was exposed to different light intensities and the rate of photosynthesis was estimated by counting the number of bubbles of gas produced per minute. The results are shown in the table overleaf.

Light intensity (units)	0	1	2	3	4	5	6	7
Average number of bubbles per minute	0	7	14	20	25	27	27	27

(a) Complete a line graph of the results, marking the scale on each axis.

(b) With reference to the line graph you have drawn, describe the effect on the rate of bubbling of increasing the light intensity from 5 units to 7 units.

(c) Suggest a method for increasing the light intensity in this experiment.

____

____

____

____

(d) The number of bubbles per minute for each light intensity was counted four times and an average calculated. Explain why this is a good experimental technique.

____

____

____

____

____

(e) What gas forms the bubbles in this investigation? ________________

Write a word equation describing how plants make their own food through photosynthesis:

____

7. Science in relation to the general curriculum

Areas of experience in the junior cycle

At post-primary level, teaching and learning tends to be focused on discrete subject areas. To provide a wider educational context for the various subjects in a school's curriculum, a broad and wide-ranging framework has been developed for the junior cycle, based on eight areas of experience. This framework incorporates the curricular principles of breadth, balance, relevance and coherence.

While the study of science as a subject takes place in the specific context of one of these areas of experience, it is important to take into account the broader context of the overall framework described above. Science education is one component of a general education and as such may contribute to the overall aims of education in the development of the full potential of the student as an individual. Therefore, science should be linked with other curriculum areas where possible and appropriate. To facilitate this, a short description of how science relates to each of the eight areas of experience is given below.

(i) Language, literature and communication

Practical or experimental work carried out by students provides opportunities for them to experience and practise language and communication skills. They can develop their language skills and vocabulary through discussion of work in hand and through making verbal and written reports of observations, results and conclusions.

Listening to the teacher's instructions, or explanations or ideas from other students, can help to develop the student's ability to clarify and form his/her own ideas. By means of investigative work in the laboratory, the students' curiosity can be aroused and the need to know or a desire for knowledge can encourage students to use library sources to research information. Their reading skills and interest in reading may be developed further by referring students to works of fiction which have a scientific theme, to science fiction or to lives of famous scientists. Writing skills can be developed through recording their observations and measurements, and when preparing reports of investigations.

(ii) Mathematical studies and applications

The study of mathematics is fundamental to the study of science. Study of these subjects will help to develop similar skills of logic and reasoning. Practical or experimental work in science will also help to develop mathematical skills of numeracy and graphicacy. Examples of this might include recording and presenting results in chart or graph form, reading measurements accurately, use of positive and negative numbers, use of formulae, estimation and measurement of length or volume, analysing data and solving problems.

Mathematical models are regularly used in science to simulate real events, to investigate particular patterns or phenomena, or to provide a basis for a hypothesis. Statistical analysis of recorded data can aid in forming inferences or in establishing the basis for further, more precise investigation.

(iii) Science and technology

Modern technology has as its basis the application of scientific principles to the solution of problems. Science attempts to explain how and why things work. Advances in pure scientific research provide new information and knowledge. It is the ongoing application of these findings which leads to advances in technology. Science and technology make an enormous contribution to the agricultural, industrial and economic development of the world. The development of new materials, processes and techniques has, in the main, been based on research and development of a scientific nature. The application of science in areas such as electronics, electricity, food and microbiology, and the development and use of computers, address significant areas of the interface between science and technology.

(iv) Social, political and environmental education

Changing perceptions of the world and the universe and changing relationships between humans and their environments have been greatly influenced by scientific research and development. Information about famous scientists, their lives and times and their contribution to science and society can lead to an appreciation of science in a historical context.

Students can be encouraged to consider the impact that scientific discoveries have had on our world and their influence on our daily lives. Topics such as the weather, soil, water, pollution, waste disposal/management, transport, genetic engineering, etc., which may arise in other subject areas, can prove to be a valuable stimulus for science investigations.

(v) Arts education

Music can help to illustrate a science topic while at the same time science can help the musician to understand the making of music. This can be achieved through such topics as investigating sound and pitch, and making simple musical instruments. In art, as in science, students can develop their spatial awareness and their ability to observe, as well as their ability to communicate these observations by means of drawing and sketching. The study of light and colour, photography, and textiles provide natural links between science and the arts.

(vi) Physical education

Through the study of the human body matters such as personal hygiene (e.g., care of teeth) and healthy eating habits (arising from a study of nutrition) can be encouraged. Positive attitudes to health and fitness can be developed through scientific themes, for example, the human body and the environment. Health issues (for example, heart disease, cancer and pollution) and the study of the outdoor environment can help students to develop positive attitudes to environmental health and healthy living. Physical fitness and sport can be related to science in areas such as the investigation of movement and studies on the effect of exercise on breathing and heart rate.

(vii) Religious and moral education

The ever-increasing influence of science on our world and environment, and the extent to which discoveries in science and technology can lead to greater control of all aspects of our lives, mean that decisions about the appropriate use of such developments should be informed by moral values. As citizens, we should be equipped to enter discussions about, and make personal judgements on, issues related to the impact of science and technology on our lives, on society and on the environment.

Advances in medicine and the rapid expansion and development in the pharmaceutical and chemical industries, as well as the ever-expanding knowledge of the human body, will require that decisions which seriously impact on life itself should be influenced by a religious and moral dimension, and not solely by scientific or economic considerations.

(viii) Guidance, counselling and pastoral care

Developments in science and technology play an increasingly pivotal role in our cultural, social and economic lives. These developments give rise to the need for a more highly educated and skilled work force. Many opportunities arise for careers in science and in science-related industries. All students should be encouraged to study science and to develop scientific literacy, so they will be better prepared to respond to and control the influences that science will have on their lives and environment.

The pace of change associated with scientific progress can have a dramatic effect on the individual, sometimes giving rise to feelings of unease and uncertainty. Education in and about science, together with appropriate guidance, can play a significant part in preparing all citizens for the challenges posed by the rapid changes which inevitably accompany such progress.

8. Suggested useful apparatus and materials

The following resources list of apparatus and chemicals was sent by the Department of Education and Science to schools with the circular introducing the revised syllabus. The list sets out the minimum resources needed to implement the hands-on approach to practical work, as required in the revised syllabus. The list is indicative only, and it is neither prescriptive nor exhaustive. Valid alternatives are available for some of the items listed. The list does not include some common items that can be sourced at local level. The primary purpose of the list is to help schools assess their resource needs.

The quantities and equipment and materials are, in most cases, those required for 12 groups of students. While ideally all experiments and investigations should take place in groups of two students, it is open to the class teacher to provide for fewer groups with more students if he/she considers that this approach is required for certain experiments or investigations in the particular circumstances of the school. The quantities of chemicals listed are those normally provided by the chemical suppliers.

Equipment	Quantity per lab
Balance	3
Ball and ring	6
Bar magnets (pair)	12
Battery	12
Beaker	48
Bell in bell jar apparatus	1
Bi-metal strip	6
Bulb	12
Bulb holder	12
Bunsen	12
Burette	12
Buzzer	12
Clamp + bosshead	24
Clay-pipe triangle	12
Clock glass	12
Conical flask	12
Crocodile clip	50
Crucible and lid	12
Diode	24
Dissection board	12
Distillation apparatus	8
Dropping bottle	50
Dropping pipette	72
Electrodes (2)	12
Evaporating basin	12
Filter funnel	12
Filter pump	6
Forceps (blunt)	12
Fuse wire (roll)	1

Glass block	12
Glass tubing (various)	1
Graduated cylinder	12
Heat mat	20
Inoculating loop	12
Kettle	2
Leads	48
LED	24
LF a.c. generator	1
Light pen	12
Light source	12
Lux meter	1
Magnifying glass	12
Metal rods (3)	12
Metal tongs	15
Metre stick	12
Microscope	12
Microscope cover slip (box)	1
Microscope slide (box)	1
Mirror plane	24
Mortar and pestle	12
Multimeter	24
Newton balance	12
Overflow can	12
Parafilm (roll)	1
Petri-dish	100
Pipette	12
Pipette filler	12
Plastic basin	12
Plotting compass	24
Pooter	25
Potentiometer	12
Prism	12
Quadrat	12
Resistor	24
Retort stand	16
Round bottomed flask	12
Rubber/propylene tubing (various)	1
Safety glasses	24
Sample bottle	48
Scalpel blade	30
Scalpel	12
Scissors (blunt)	12
Set of weights	12
Slide box	1
Small motor	12
Soil thermometer	6
Solar cell kit	12
Sound level meter	1
Spatula	24

Spring	12
Stirring rod	24
Stop watch	12
Stopper (various)	48
Switch	12
Syringe plastic	12
Test-tube	100
Test-tube holder	24
Test-tube rack	12
Thermometer	12
Transect	12
Tripod	12
Tuning fork	12
White dropping tile	25
Wire gauze	12

General materials	Quantity per lab
Aluminium foil (roll)	1
Anaerobic jar	1
Biological species keys	24
Candles (pack)	1
Chromatography paper (roll)	1
Cobalt chloride paper (pack)	1
Cotton wool (pack)	1
Disclosing tablet (box)	1
Disposable glove	100
Filter paper (box)	1
Food dyes (various)	1
Incubator	n/a
Ion exchanger	n/a
Litmus paper (box)	1
Measuring tape	2
Model of torso	n/a
Molecular models	1
pH paper (box)	1
Plant mineral deficiency test kit	1
Plastic bag	100
Prepared slide	4
Reagent bottle	48
Refrigerator	n/a
Respiration apparatus	1
Skeleton	n/a
Steel wool (pack)	1
Sweeping net	2
Thermos flask	2
Tullgren funnel	1
Universal indicator paper (box)	1
Volumetric flask	4
Wooden splint (box)	1
Wormery	1

Chemicals	Quantity
Agar powder	200g
Aluminium sulfate	500g
Amylase	25g
Benedict's solution	500ml
Calcium carbonate (marble chips)	1kg
Calcium chloride	500g
Calcium hydroxide	500g
Calcium sulfate	500g
Calcium turnings	50g
Carbon (charcoal)	500g
Copper sulfate	500g
Copper turnings	500g
Glucose powder	500g
Hydrochloric acid	2.5l
Hydrogen peroxide	500ml
Iodine	500ml
Iron filings	500g
Lithium	10g
Magnesium ribbon	25g
Manganese dioxide	500g
Methylated spirits	2.5l
Methylene blue	100ml
Paraffin wax	1kg
Phenolphthalein indicator	25g
Potassium	10g
Potassium iodide	100g
Soda lime	500g
Sodium	10g
Sodium hydroxide	500g
Sodium metabisulfite	100g
Starch powder	500g
Sulfur	500g
Sulfuric acid	2.5l
Universal indicator	500ml
Zinc	500g

Appendix 1

Junior Certificate Science

Sample reporting booklet for the assessment of coursework (set investigations)

Junior Certificate Science

Coursework A

Biology		
Reference	**Mandatory investigations and experiments**	**Date completed**
OB3	Carry out qualitative food tests for starch, reducing sugar, protein and fat.	
OB5	Investigate the conversion of chemical energy in food to heat energy.	
OB8	Investigate the action of amylase on starch; identify the substrate, product and enzyme.	
OB11	Carry out qualitative tests to compare the carbon dioxide levels of inhaled and exhaled air.	
OB39	Investigate the variety of living things by direct observation of animals and plants in their environment; classify living organisms as plants or animals, and animals as vertebrates or invertebrates.	
OB44	Prepare a slide from plant tissue and sketch the cells under magnification.	
OB49	Show that starch is produced by a photosynthesising plant.	
OB58	Investigate the conditions necessary for germination.	
OB59	Study a local habitat, using appropriate instruments and simple keys to show the variety and distribution of named organisms.	
OB65	Investigate the presence of micro-organisms in air and soil.	
Ref. code		
Ref. code		
	Number of completed biology items	

Junior Certificate Science

Coursework A

Chemistry		
Reference	**Mandatory investigations and experiments**	**Date completed**
OC2	Separate mixtures using a variety of techniques: filtration, evaporation, distillation and paper chromatography.	
OC17	Grow crystals using alum or copper sulfate.	
OC19	Investigate the pH of a variety of materials using the pH scale.	
OC22	Show that approximately one fifth of the air is oxygen; show that there is CO_2 and water vapour in air.	
OC24	Prepare a sample of oxygen by decomposing H_2O_2 using MnO_2 as a catalyst.	
OC27	Prepare carbon dioxide and show that it does not support combustion.	
OC30	Conduct a qualitative experiment to detect the presence of dissolved solids in water samples, and test water for hardness (soap test).	
OC38	Titrate HCl against NaOH, and prepare a sample of NaCl.	
OC46	Carry out an experiment to demonstrate that oxygen and water are necessary for rusting.	
OC51	Investigate the reaction between zinc and HCl, and test for hydrogen.	
Ref. code		
Ref. code		
	Number of completed chemistry items	

Junior Certificate Science

Coursework A

Physics		
Reference	**Mandatory investigations and experiments**	**Date completed**
OP2	Measure the mass and volume of a variety of solids and liquids and hence determine their densities.	
OP6	Investigate the relationship between the extension of a spring and the applied force.	
OP20	Identify different forms of energy and carry out simple experiments to show the following energy conversions: (a) chemical energy to electrical energy to heat energy (b) electrical energy to magnetic energy to kinetic energy (c) light energy to electrical energy to kinetic energy.	
OP23	Investigate and describe the expansion of solids, liquids and gases when heated, and contraction when cooled.	
OP31	Carry out simple experiments to show the transfer of heat energy by conduction, convection and radiation; investigate conduction and convection in water.	
OP34	Show that light travels in straight lines.	
OP38	Investigate the reflection of light by plane mirrors, and illustrate this using ray diagrams; demonstrate and explain the operation of a simple periscope.	
OP46	Plot the magnetic field of a bar magnet.	
OP49	Test electrical conduction in a variety of materials, and classify each material as a conductor or insulator.	
OP50	Set up simple electric circuits; use appropriate instruments to measure current, potential difference (voltage) and resistance, and establish the relationship between them.	
Ref. code		
Ref. code		

Number of completed physics items	

Junior Certificate Science

Coursework B

Reporting on the investigations

(Set by the State Examinations Commission)

Selected Investigation

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Junior Certificate Science

Report on Coursework B Investigation

Period in which the investigation was carried out

Introduction to the investigation (including background research undertaken in preparation for the investigation: people, books, websites, etc. as sources of relevant information)

Junior Certificate Science

Report on Coursework B Investigation

Preparation and planning

(i) identification of variables/controls

(ii) List of the equipment needed for the investigation

(iii) List of tasks to be carried out during the investigation

Junior Certificate Science

Report on Coursework B Investigation

Particular safety precautions required by this investigation

Labelled diagram (where appropriate)

Procedure followed in the investigation

Junior Certificate Science

Report on Coursework B Investigation

Labelled diagram (where appropriate)

Procedure followed in the investigation (continued)

Junior Certificate Science

Report on Coursework B Investigation

Recorded data / observations

Junior Certificate Science

Report on Coursework B Investigation

Calculations / Data analysis

Conclusions and Evaluation of Results

Junior Certificate Science

Report on Coursework B Investigation

Comments (refinements, errors, etc.)

Use this additional space, if required, to complete any aspect of your report

Report on Coursework B Investigation

Use this page as a continuation of page B7, if required

Appendix 2

Junior Certificate Science

Sample reporting booklet for the
assessment of coursework
(investigation chosen by the candidate)

Junior Certificate Science
Coursework A

Biology		
Reference	**Mandatory investigations and experiments**	**Date completed**
OB3	Carry out qualitative food tests for starch, reducing sugar, protein and fat.	
OB5	Investigate the conversion of chemical energy in food to heat energy.	
OB8	Investigate the action of amylase on starch; identify the substrate, product and enzyme.	
OB11	Carry out qualitative tests to compare the carbon dioxide levels of inhaled and exhaled air.	
OB39	Investigate the variety of living things by direct observation of animals and plants in their environment; classify living organisms as plants or animals, and animals as vertebrates or invertebrates.	
OB44	Prepare a slide from plant tissue and sketch the cells under magnification.	
OB49	Show that starch is produced by a photosynthesising plant.	
OB58	Investigate the conditions necessary for germination.	
OB59	Study a local habitat, using appropriate instruments and simple keys to show the variety and distribution of named organisms.	
OB65	Investigate the presence of micro-organisms in air and soil.	
Ref. code		
Ref. code		
	Number of completed biology items	

Junior Certificate Science
Coursework A

Chemistry		
Reference	**Mandatory investigations and experiments**	**Date completed**
OC2	Separate mixtures using a variety of techniques: filtration, evaporation, distillation and paper chromatography.	
OC17	Grow crystals using alum or copper sulfate.	
OC19	Investigate the pH of a variety of materials using the pH scale.	
OC22	Show that approximately one fifth of the air is oxygen; show that there is CO_2 and water vapour in air.	
OC24	Prepare a sample of oxygen by decomposing H_2O_2 using MnO_2 as a catalyst.	
OC27	Prepare carbon dioxide and show that it does not support combustion.	
OC30	Conduct a qualitative experiment to detect the presence of dissolved solids in water samples, and test water for hardness (soap test).	
OC38	Titrate HCl against NaOH, and prepare a sample of NaCl.	
OC46	Carry out an experiment to demonstrate that oxygen and water are necessary for rusting.	
OC51	Investigate the reaction between zinc and HCl, and test for hydrogen.	
Ref. code		
Ref. code		
	Number of completed chemistry items	

Junior Certificate Science
Coursework A

Physics		
Reference	**Mandatory investigations and experiments**	**Date completed**
OP2	Measure the mass and volume of a variety of solids and liquids and hence determine their densities.	
OP6	Investigate the relationship between the extension of a spring and the applied force.	
OP20	Identify different forms of energy and carry out simple experiments to show the following energy conversions: (a) chemical energy to electrical energy to heat energy (b) electrical energy to magnetic energy to kinetic energy (c) light energy to electrical energy to kinetic energy.	
OP23	Investigate and describe the expansion of solids, liquids and gases when heated, and contraction when cooled.	
OP31	Carry out simple experiments to show the transfer of heat energy by conduction, convection and radiation; <u>investigate conduction and convection in water.</u>	
OP34	Show that light travels in straight lines.	
OP38	Investigate the reflection of light by plane mirrors, and illustrate this using ray diagrams; demonstrate and explain the operation of a simple periscope.	
OP46	Plot the magnetic field of a bar magnet.	
OP49	Test electrical conduction in a variety of materials, and classify each material as a conductor or insulator.	
OP50	Set up simple electric circuits; use appropriate instruments to measure current, potential difference (voltage) and resistance, and establish the relationship between them.	
Ref. code		
Ref. code		
	Number of completed physics items	

Junior Certificate Science
Coursework B

Reporting on the investigation

(Candidate's own choice of investigation)

Title of the investigation
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My interest in carrying out this investigation
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Period in which the investigation was conducted
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Junior Certificate Science
Coursework B Investigation

Introduction to the investigation

Aim of my investigation

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Statement of the identified task/problem

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Background research undertaken in preparation for the investigation: people, books, websites, etc. as sources of relevant information)

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Junior Certificate Science
Coursework B Investigation

Preparation and planning

(i) Identification of variables/controls

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(ii) List of the equipment needed for the investigation

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(iii) List of tasks to be carried out during the investigation

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Pages B4, B5 and B6 should be used to describe the procedure followed in conducting the investigation. Each page allows the inclusion of a labelled diagram, showing the apparatus or equipment used where appropriate.

Junior Certificate Science
Coursework B Investigation

Labelled diagram (where appropriate)

Particular safety precautions required by this investigation

Junior Certificate Science
Coursework B Investigation

Labelled diagram (where appropriate)

Procedure followed in the investigation

Junior Certificate Science
Coursework B Investigation

Labelled diagram (where appropriate)

Procedure followed in the investigation (continued)

Junior Certificate Science
Coursework B Investigation

Recorded data / Observations

Calculations / Data analysis

Junior Certificate Science
Coursework B Investigation

Conclusions and Evaluation of Results

Junior Certificate Science
Coursework B Investigation

Comments (refinements, errors, etc.)

Junior Certificate Science

Coursework B Investigation Report

Use this page as a continuation of page B9 if required.

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