New edition

Integrated Science

for Caribbean Schools

Teacher's Guide

Heinemann

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1 Introduction

Observation, experimentation, interpretation and validation form the basic steps of scientific and technological enquiry. The use of these tools is therefore an integral component of the new *Integrated Science for Caribbean Schools* series. These skills cannot develop in a vacuum, and the cognitive development of the student has to go hand in hand with scientific and technological development. The three books in the series are arranged using themes and topics in an integrated approach so that some measure of conceptual development, together with analytical and evaluative skills, can be achieved by all students. Carefully focused activities ensure that students acquire skills in problem solving and critical thinking.

Technology is an integral part of human development. The authors have included technology specific to the Caribbean area and, through exercises, have set the stage for the development of innovative thought from both teachers and students. Students are encouraged to use new technology, computers and the internet to access materials and to visit places where technology is used in everyday life and for more specialised purposes.

Students are also encouraged to be inventors and innovators. Many secondary schools have technology departments where students' can turn ideas into prototypes and their designs can then be tested for suitability and practicability. Some private companies and government departments will also give assistance in this area of school/community collaboration.

This type of activity forms the foundation for the more advanced work required at the higher levels, where students are expected to plan and design using their ideas and concepts. The *Integrated Science for Caribbean Schools* series provides a firm foundation in science education for all lower secondary school students, particularly those going on to study for CSEC examinations.

The social, moral and environmental effects of science and technology have also been addressed throughout the books, through fact-finding research, discovery items, and discussions. As students acquire knowledge, there should be a marked positive change in attitudes and values, allowing for the growth of the individual and thus fostering a solid foundation for the future sustainable development of the region.

As a teacher, you are encouraged to use both the formal and non-formal sectors as resource bases for assistance in the sourcing of information and materials. Many groups in the non-formal sector will willingly assist with nature walks, hikes, round-table/panel discussions, and 'buzz' group sessions. It is important to arrange prior consultation with those giving assistance and to draw up a relevant work plan before any exercise is undertaken.

Mathematical concepts and principles are also important to the successful realization of scientific and technological thoughts and precision of presentations. Mathematics has been integrated into appropriate areas of the three student books, strengthening a positive perception of mathematics as a tool of the scientific process.

Much of the subject matter of the *Integrated Science for Caribbean Schools* books can be carried into other subject areas. Teachers are encouraged to look at 'team teaching' as a part of handling the curriculum. Encourage students to write in standard English and to write about subject matter from their science lessons in other areas of the curriculum. Some of the information can be taught or evaluated by having the students write poetry, make a dramatic presentation of a topic, express themselves through dance or art, and so on. Suggestions have been made for such activities, and of course you can prepare similar activities in other areas.

The same framework is used in each unit of the three student books. The units are divided into topics. Each topic begins with clearly set out objectives and finishes with a summary section, followed by questions that help students to consolidate their knowledge and understanding. By the end of year 1, and throughout years 2 and 3, you should see the students acquiring the following skills:

- leadership
- team building
- organization
- research
- safety awareness
- communication
- creativity
- working with materials
- critical thinking
- problem solving.

Tests at the end of each book develop those skills required for assessment.

This *Teacher's Guide* provides additional information on safety, suggested teaching strategies, and advice on teaching particular subjects. It also contains the answers to the multiple-choice and the short-answer questions at the end of each student book.

2 Safety information

One might expect the laboratory to be a dangerous place. After all, teachers, technicians and students are handling potentially dangerous materials and equipment. Fortunately, the number of accidents is small compared with physical activities such as football, athletics and cricket. When accidents do occur, however, the name of the school and the teachers can be highlighted in the local press and there may be repercussions.

The Head of Department is crucial in setting a good example and monitoring that the other teachers are doing the same. Health and safety issues should be discussed in departmental meetings, and relevant information should be given to new teachers, student teachers and other visitors. In fact, it is good practice to have an agreed and written departmental safety policy.

You should carry out a risk assessment of any practical activity before tackling it with students, and should identify any hazards associated with procedures. This is obvious with chemicals because the course identifies hazardous chemicals; for example ethanol is highly flammable. A risk assessment should also look at the type and size of the room, the number of students who will be involved in the activity, ventilation, use of equipment with sharp edges, poorly maintained equipment (e.g. electrical equipment with loose wiring in the plug), your own expertise, and the behaviour of the students. You must also decide on the level of personal protective equipment required. In schools and colleges, eye protection is mandatory. If you feel that the activity cannot be done by the students, then you could use other strategies such as doing a demonstration yourself, asking a technician to demonstrate, or showing a video.

The most effective approach seems to be to include the results of the risk assessment in schemes of work and to highlight the essential features in the student's worksheets. In general, students should not be left unsupervised in the laboratory. You should ensure that students know what to do in an emergency such as a fire. Make sure you know the escape route from the classroom, the location of fire-fighting equipment and the nearest first aid kit, and where to turn off the gas and electricity at the main supply to the laboratory. Laboratories must be left safe and all machinery, gas taps and electrical apparatus must be turned off when not in use. If any equipment needs to be left running for a particular experiment, then special arrangements must be made.

At the beginning of the school year make sure that students have a copy of the school safety rules for working in the science lab.

These should be stuck into their exercise books or placed in a work folder for easy reference.

It might seem tempting to avoid all practical work in order to reduce the risk of injury to zero. However, education is training for life. Students will come into contact with hazardous chemicals and equipment throughout their lives. Learning to recognize and cope with such situations is a part of their science education.

Safety icons

The following symbol is a mandatory symbol, showing when eye protection must be worn.

The following are standard hazard warning symbols that students are likely to encounter in the laboratory (and in everyday life). They are used in the *Integrated Science* student books to warn of any hazards associated with the activities.

Corrosive	Toxic	Harmful or irritant	Highly flammable	Oxidizing	Danger! Care needed!

3 Lesson planning

Planning is vital to the delivery of a good lesson

You will have a clear idea of the knowledge that students should already have when they come into the lesson, as this serves as the foundation upon which the new knowledge is built. You can then organize materials, content, methodology and assessment strategies. Instructional objectives focus your mind on the why, what, how, where and when of the lesson. Behavioural objectives give you a vision of expected student achievement, and serve as a good springboard for your own and the students' assessment of the lesson.

Behavioural verbs frequently used for science teaching include: classify, construct, define, demonstrate, distinguish, estimate, evaluate, identify, interpret, locate, manipulate, measure, predict, name, solve and state. These verbs signify observable behaviours that are measurable at the end of a period of time. For example:

'At the end of the lesson students should be able to:

- measure a line accurately and make a scale
- construct a simple weighing machine
- state why it is important to follow instructions
- demonstrate the use of a simple weighing machine.'

Introducing the lesson – heads down and focus

At the start of a lesson, we often have to gather equipment ready for a demonstration, put our notes in order, give out papers to particular students, and so on – the list is endless. Not only do these activities take up useful teaching time but they can also give the class an opportunity to chat or display other forms of unpurposeful behaviour.

It is helpful to begin the lesson with a brief 'starter activity' that will focus the students' minds on the topic of the forthcoming lesson. This should be a brief task that students carry out individually, setting the context of the lesson and helping to remove students from the more social world outside the classroom. It is best to have the task ready for when the students arrive, perhaps written on the board or on an overhead projector transparency. Whilst the students are doing the activity, you have time to deal with any organisational or administrative tasks.

Examples might be:

- Sketch a diagram to show how energy stored in oil becomes available to us at the flick of a switch.
- List the foods you have eaten in the last 24 hours under the headings: carbohydrates, fats, proteins, etc.

Students will quickly understand the purpose of these tasks, and will expect an activity to be set at the start of a lesson. You will be able to draw on their ideas during the lesson.

Methodology

The methods that will be used for content delivery should be carefully thought out before the actual lesson. You should be clear in your mind whether the lesson will be a lecture/discussion type session, whether there will be an exploratory discussion session at the start of the lesson, leading into a practical enquiry session, if additional material will be required based on the cognitive level of the students or if worksheets need to be prepared for the class session. A carefully thought out methodology helps to alleviate teacher attrition in the classroom. A word of caution for the new teacher – try out experiment(s) before doing them with your students.

Finishing off

Make sure that you leave enough time for a well-structured summing up at the end of the lesson. A lesson that finishes with a mad scramble to put equipment away and tidy up is unlikely to make a valuable impression on a student's mind.

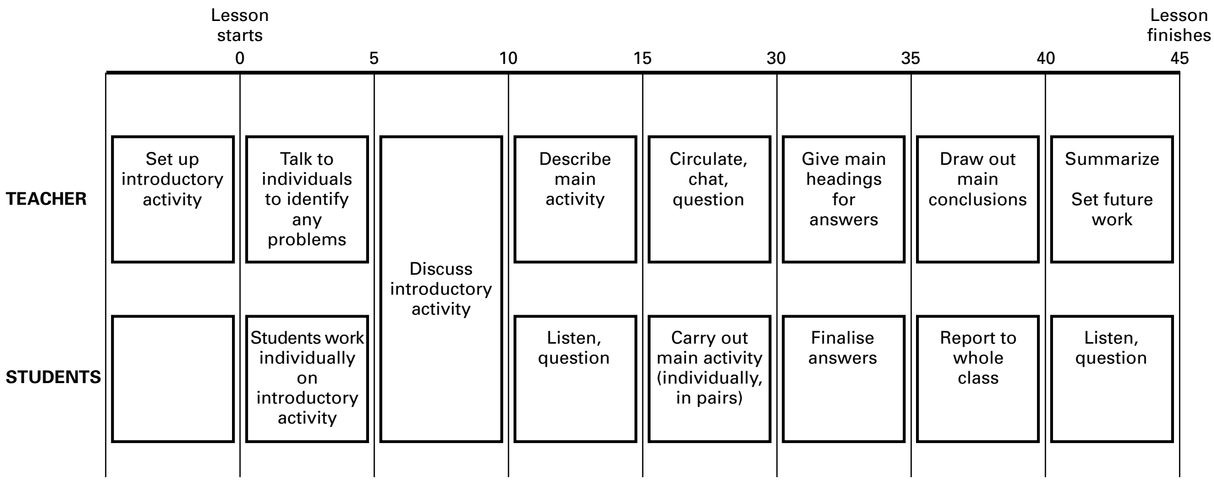
The closing minutes of a lesson can serve two purposes:

- to review and summarize what has been learned – if you have stated a clear objective at the start of the lesson, students will see that this has been achieved;
- to look ahead to the next lesson or lessons – although students may not realize it, by priming them gently their minds are likely to spend some time thinking about the next topic.

Homework is likely to be linked to one of the above objectives, and can be introduced during your summing up.

Lesson overview

It can be a great help to have a picture in your mind of how a lesson is going to progress. What will you be doing? What will the students be doing? The following diagram shows one typical lesson structure, incorporating some of the ideas above.



Of course, each lesson will have its own structure, depending on what you hope to achieve. Try drawing a diagram like the one above at the end of one or two of your own lessons. Every teacher has his or her own style; it can help students if you bring a little variety to your lessons by making them flow differently from time to time. Try introducing different elements into your standard approach.

Assessment

Questioning is an important part of the lesson process and should be linked to the objective(s) of the lesson. Questions test the students' understanding, retention of information and ability to manipulate this information in similar or new circumstances. Questions may be low order – knowledge and comprehension – or higher order – analysis/interpretation and evaluation. An example of each type follows:

- Knowledge – 'Describe the water cycle.'
- Comprehension – 'What causes cloud formation?'
- Analysis/interpretation – 'Given the following data, predict what would take place when … .'
- Evaluation – 'Should housing development be allowed in the water catchment area? Give reasons for your answer.'

Planning a field trip

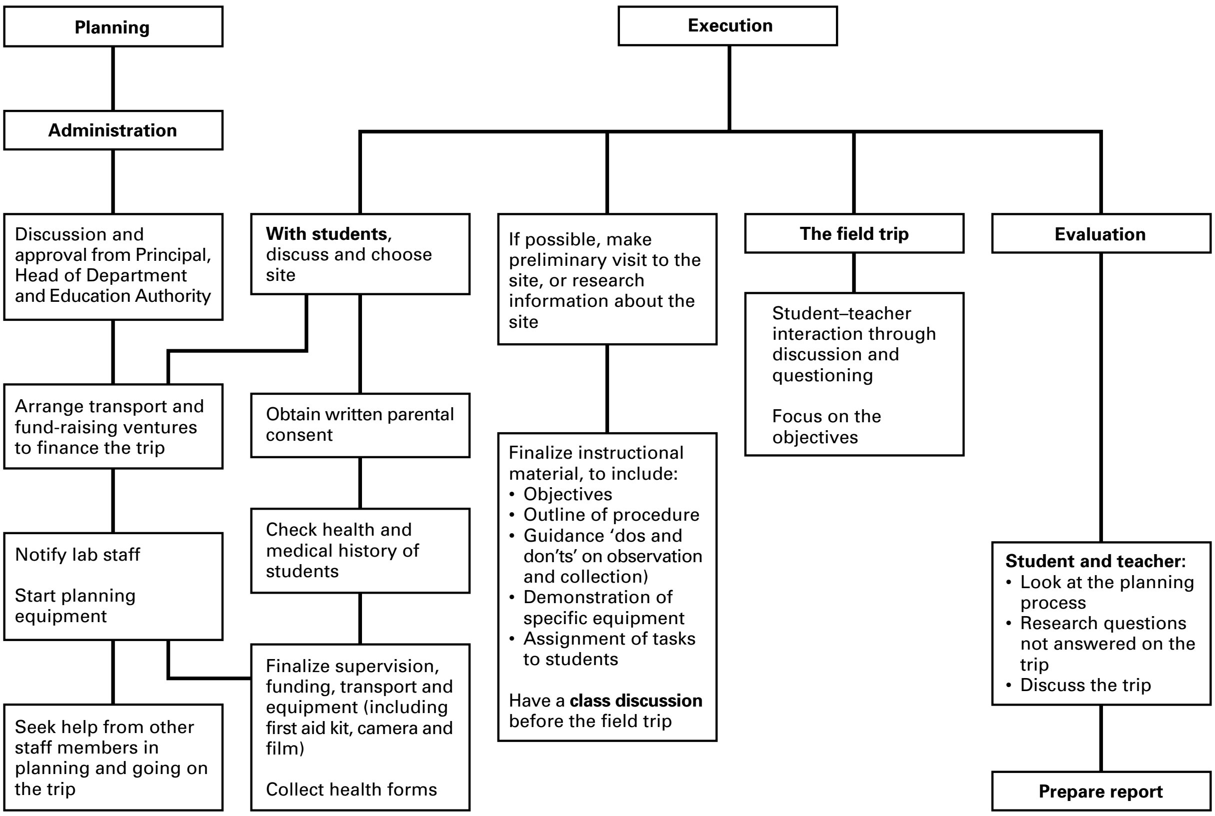
All stages of the lesson planning process should be clearly identified. The flow chart on page 8 shows the detailed planning for a field trip. Note that managerial objectives have been included with the instructional and behavioural objectives. By flow charting the activities of the lesson, you can check for:

- prior knowledge required by the students
- gaps and overlap in lesson content

- areas where team teaching might be more effective
- the need for prior preparation of equipment and materials
- critical issues relating to effective delivery.

Remember to allow sufficient time to prepare for the trip, to arrange transport and to order any pieces of equipment that might be required. You should make a preliminary visit to the site, and research what you want to do on the trip. Set clear objectives for the students, assign tasks and discuss instructions with them before you leave. Make sure they have the relevant safety information and appropriate clothing.

During the field trip you should work with the students to collect enough information to achieve the objectives of the trip. After the field trip, you should evaluate the planning process and the organization of the trip. Also discuss the trip with the students. The students should prepare their own report, saying what their objectives were and how far these were met by the research on the field trip.



Reference material

It is good practice to have a list of the reference material used for the preparation of the lesson. A list of suitable websites is included in this *Teacher's Guide* to get you started.

Help from the Association for Science Education (UK)

The UK's Association for Science Education (**www.ase.org.uk**; Association for Science Education, College Lane, Hatfield, Hertfordshire, AL10 9AA UK. Fax + 44 1707 266 532 headquarters: + 44 1707 283 000) produces many materials to support science education. The following series of books give a general overview of their subject, together with detailed teaching approaches, ideas for activities, extension material, and further resources.

- *Teaching Secondary Physics* – ISBN 07195 7636 9
- *Teaching Secondary Biology* – ISBN 07195 7637 7
- *Teaching Secondary Chemistry* – ISBN 07195 7638 5
- *Teaching Scientific Enquiry* – ISBN 07195 8618 6

4 Guidance on selected topics

Socio-dynamics – getting the best from your class

This activity is about establishing the socio-dynamics of a class of students. Simple techniques such as this one go a long way in teaching responsibility and developing the decision-making and problem-solving processes.

Rationale

Group work and partnering are key tools for laying the foundation of team work. Group work is also a good class management tool. These functions become critical in laboratories where there is a space constraint or a shortage of materials and equipment.

Objectives

- To introduce students to each other
- To establish effective working teams of students

Materials

- The students
- The class register
- Student profiles, if available from cumulative record cards (note that some of this information may be sensitive and may need to be handled discreetly)
- Activities: 'Bursting balloons' (Student Book 1, page 1) and 'Making a simple weighing machine' (Book 1, page 2).

Method

Ask the students to choose a partner to work with. Students do the class activity 'Bursting balloons'. Observe the interaction between the partners and make notes about the various pairs: which pairs settle down to the task quickly, in which pairs there is a sharing of the activity, who the dominant partner is in the pair, how well the personalities are balanced, and so forth. You can then use this information to put pairs together to form larger groups, which will then prepare to do the activity 'Making a simple weighing machine'. Each pair in the group can be given specific tasks. For example, one pair can be asked to source the wood and prepare the pieces as in the diagram. The other pair can be responsible for getting the other materials listed. On the day of the activity, the two pairs come together to construct the measuring device.

A word of caution: Do not give this activity for homework, as it becomes an assignment for the enthusiastic parent, not the student!

After completing the activity, ask the students to comment on their group's performance. This will serve as a guide to the interaction process, and whether there is need to change partners or for counselling. You can then assign members of the group to specific tasks that will make best use of their social abilities to help others in the class or school. The tasks can be reassigned as the term progresses, giving each student an opportunity at each role. The following assignments are suggested.

- A **group leader** ensures that each person has the correct books for class. This task is important as some of the younger students may find it difficult at first to follow the time table. Initially this task can be given to a student showing strong leadership ability.
- A **group technician** ensures that the group has the correct materials to complete a task.
- **Task masters** ensure that the task is done according to the instructions.

Health

Make sure you are aware of any health problems or conditions that students may have before asking them to undertake physical activity as part of an experiment.

Chemistry

General

Care should always be taken when heating materials; such experiments should take place in a well-ventilated room. Eye protection should be worn to protect against smoke and spitting. Be aware that gases given off during heating or when chemicals are combined may be toxic and so be sure that students know the correct way to 'smell' these gases. For example, in Book 3, Topic 14.6: Metals from minerals (page 28), the gases given off when iron sulphide or lead sulphide is heated are toxic. In the electrolysis of copper(II) chloride (Book 3, page 29), toxic chlorine gas is produced.

Concentrations of solutions

Make sure you know the concentration of the solutions you are using in experiments. Use the lowest concentration that produces the desired result (see Table 1 for guidance). Make sure an experiment works before doing it with your students.

Table 1

Topic	Activity	Page reference	Notes
9.7 Acids and alkalis	Finding out pH values	Book 2, page 27	Use 0.1 M solutions of the reagents; about 1 cm of each solution poured into a test tube is all that is needed for the tests
	Neutralizing an alkali	Book 2, page 28	0.1 M concentrations of the solution are recommended
	Making a salt	Book 2, page 30	1 M solutions of sodium hydroxide and of nitric acid are recommended so that a solid is produced
9.8 Acids and metals	Acids and metals	Book 2, page 32	Do **not** use nitric acid; 1 M hydrochloric acid and 0.5 M sulphuric acid are suggested
	What's the gas?	Book 2, page 33	Use 1 M sulphuric acid
9.9 Salts	How carbonates react with acids	Book 2, page 35	Use 0.5 M sulphuric acid, 1 M hydrochloric acid, 1 M nitric acid, 0.1 M calcium hydroxide, 0.1 M sodium carbonate
	A metal oxide and an acid	Book 2, page 36	Use 0.5 M sulphuric acid
13.1 Using electricity	Making a simple cell	Book 2, page 143	0.1 M sulphuric acid should be adequate
14.6 Metals from minerals	Splitting up copper(II) chloride	Book 3, page 29	A 0.1 M solution should work as well as the 1 M solution that is made by dissolving 10 g copper(II) chloride in 50 cm^3 water

What part of the air is used in burning a candle?

The activity 'What part of the air is used up in burning' in Topic 10.1: Air as a resource (Book 2, page 38), does work, but the determinant of when the candle flame is extinguished is not always that the jar has no oxygen left but rather the moment the carbon dioxide blanket in the jar descends, putting out the flame. Conveniently, this is usually when about one-fifth of the air has gone. The experiment can be unreliable and the shape and volume of the jar can be important.

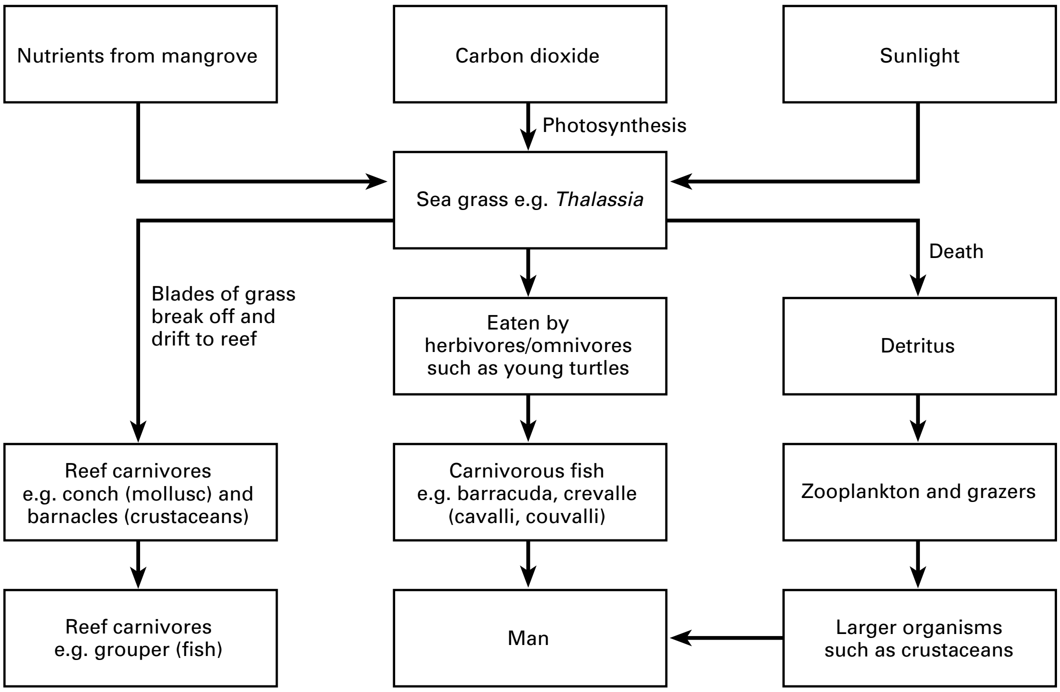
Biology

Activity 'Does all the tongue detect all tastes?' (Book 1, page 17)

The results of this experiment can be disappointing or unexpected. Every part of the tongue contains receptors for the four major tastes – sweet, sour, salt and bitter – but the numbers of each receptor differ in different parts of the tongue. As people get older the numbers of each receptor fall and so strong tastes – like curries and peppermints – are easier to distinguish.

Food webs

The following information relates to food webs but the conceptual approach it takes can be used to teach other areas effectively. A concept map such as the one shown in below can be used to forecast how the lesson will develop or to summarize the lesson during closure. It can also be used as an effective assessment tool in which you omit key pieces of information and ask the students to fill in the correct information. The chart could also be used as a tool for ongoing questioning during the lesson, for example 'Suggest an animal that would eat the grass?'. Questions could ask students to interpret the data, or to extrapolate from information given. For example, 'What would happen to the ecosystem if coastal development were to cause heavy silting of the sea grass beds?'



A food web in a sea grass bed. This web highlights the importance of sea grass beds to three interacting ecosystems.

Teaching about energy

Energy is covered in Unit 4 of Book 1.

Energy is a concept vital to all branches of science. However, it is also a term used in everyday conversation, and so we need to develop a more scientific view in our students. One problem is that energy can be seen as an abstract concept – it is a quantity that can be calculated, and which remains constant even when a change occurs in a closed system, but that's not something to tell an 11-year-old! The following ideas will help you to develop your students' ideas of energy.

Sources of energy (Topics 4.1 and 4.2)

This is a good place to start because the idea of energy is implicit in fuels and other sources of energy. Students can develop awareness of the energy sources that they use in their lives. Some of these are hard to identify; however, we don't all know where and how our electricity is generated.

Energy changes (Topic 4.3)

Energy really only matters when something is changing. We can picture the change in two ways.

- The energy can change its form. This is an energy *transformation*.
- The energy can be transferred from one place to another, or from one object to another. This is an energy *transfer*.

Topic 4.3 concentrates on energy transformations. The word 'conversion' is also used but the advantage of the word 'transformation' is that it includes the word 'form' within it. To this end, students need to build up an understanding of different

Table 2 Forms of 'moving' energy

Heat energy Light energy	We start with these because we can feel heat (for example, coming from a flame), and we can see light. A flame clearly is a source of energy, and these are the two forms of energy we get from it.
Electrical energy	We use electricity because it is a convenient way to transfer energy from place to place. In a flashlight, electrical energy is transferred from the battery to the bulb.
Kinetic energy (KE)	This is the energy of a moving object. Students will appreciate that it takes energy to start something moving. Imagine pushing a heavy car along the road. Similarly, a moving object has energy, as you would appreciate if you are hit by a cricket ball!

forms of energy. It is best to do this gradually, adding forms to the list as and when they are encountered. The forms of energy listed in Table 2 can be thought of as energy on the move, travelling from one place to another.

Now we come to forms of stored energy. An alternative term for this is potential energy (PE).

Table 3 Forms of stored or potential energy

Chemical energy	This is the energy stored in chemicals which might later react to release the energy. For example, a fuel such as oil, and oxygen react and release heat and light energy. Avoid making statements such as 'the energy is stored in the bonds'. This does not make it any clearer and may lead to confusion later. After all, it takes energy to break bonds, not to make them.
Gravitational potential energy	This is the energy of a raised object, for example a ball at the top of a slope
Elastic potential energy	This is the energy of a stretched or squashed object
Nuclear energy	This is the energy which can be released from the nucleus of an atom such as uranium; it is the nuclear equivalent of chemical energy. (The term nuclear energy is also, confusingly, used to refer to energy produced from nuclear fuels – see below.)

A confusion of terms

Unfortunately, we are overburdened with 'energy' terms, not all of which should be used to describe *forms* of energy. Usually, they can be replaced by one or more of the terms listed above. For example:

- Solar energy is energy from the Sun. Sometimes this term is used to refer to the light, heat and ultraviolet radiation that we receive from the Sun; at other times it is used to refer to the electrical energy generated from solar radiation; it is also used to refer to heating systems in which water is heated by sunlight. Confusing! It is therefore best to avoid using the term solar energy; instead use the term 'energy from the Sun'.
- Nuclear energy (and nuclear power) may refer to electricity generated from nuclear fuels.
- Alternative energy is a term with a rather vague meaning. It usually refers to energy supplies, particularly electricity, that do not come from conventional fossil-fuel sources.
- Renewable energy is a way of describing energy supplies that are never used up, for example, wind energy.

So, watch out for this confusion. Keep a strict list of correct terms for energy. It will help your students if you gradually build up a list, perhaps on a wall poster.

Heat energy or internal energy?

We can think of heat energy as energy travelling from place to place (by conduction, convection or radiation). It travels because of a temperature difference. This is the correct use of the term ‘heat energy’.

Your students may think of heat energy as ‘the energy stored by a hot object’. If you heat an object with a Bunsen flame it gets hotter – it is storing the heat from the flame. (This idea is perpetuated in the term specific heat capacity, which implies that an object has a capacity for heat.) However, this is not a very satisfactory use of the term. A better term is internal energy. When an object is heated, the particles that it consists of gain energy and move about more. The internal energy of an object is the sum of the kinetic energy and potential energy of all its particles. However, this is beyond the scope of courses at this level – the notion of internal energy can only be grasped successfully when students have developed a kinetic picture of matter.

Transferring energy

Once students have a grasp of forms of energy and their transformations, they can think in more depth about how energy is transferred from place to place. This can be:

- thermally – as heat (see Book 1, Unit 6)
- electrically (see Book 2, Unit 13)
- by doing work – by a force (see Book 3, Unit 17).

Conservation of energy

When an amount of energy is transformed to other forms, the total amount of energy remains constant. This is not something that can be proved; it is implicit in the definition of energy. We talk about all forms of energy in joules, which implies that they are all the same thing. In addition, by drawing Sankey (arrow) diagrams to represent energy transformations (for example, Figure 4.19, Book 1 page 94) we are representing the fact that energy is conserved – the width of the arrow remains constant. In this way, students will grasp the idea of energy conservation relatively intuitively. (It may help the students to discuss briefly other things that are and are not conserved. Mass is conserved (more or less): if you react 1 g hydrogen gas with 8 g oxygen, you get 9 g water. In this case, volume is not conserved: the water occupies much less volume than the gases. Similarly, colour is not conserved in a chemical reaction.)

The idea of conservation of energy can be taken further by looking for energy that ‘escapes’ or is ‘lost’ in the course of a physical or chemical change. We are usually concerned with heat energy escaping. By looking at energy efficiency (Topic 4.4), we can further emphasize the idea of conservation of energy.

Teaching about electricity

Unit 13 in Book 2 covers electricity and magnetism. You may wish to divide this topic into two or three batches spread over the first three years of secondary school.

Electricity can appear mysterious to many students (and to many adults!) because the flow of current in wires is invisible, and we cannot see any change to a battery when it is used to supply a circuit. We therefore need to give our students some physical ideas to get hold of. We can do this by using lamps and meters to show what is going on in a circuit. We can reinforce this by, for example, drawing arrows on circuit diagrams to represent the flow of current.

As is often the case in science, we need to be careful in our use of language. The term ‘electricity’ is rather vague. In everyday speech it may refer to current, voltage or energy; it would be more correct to use it to refer to the range of phenomena associated with electric currents and voltages.

Developing ideas

Here are some ideas to gradually build up your students’ understanding. Topic 13.1 looks at sources of electricity. This is a good place to start because it gives students a concrete idea of where electricity comes from. (They will already know a bit about this if you have studied Unit 4: Energy in Book 1.)

Electrical safety (Topic 13.2) provides a useful context for learning about conducting and insulating materials. These ideas are covered here because they do not require a grasp of what is going on inside wires or around circuits. Students will rarely have to connect up circuits in everyday life. Appliances are supplied with plugs fitted as standard, and the most they might have to do is to change a fuse from time to time.

Current and voltage

Topic 13.3 covers electrical circuits – harder ideas to grasp! Students are likely to confuse the concepts of current and voltage (potential difference, p.d.). The following approach will help them with this.

- Always refer to a flow of current *through* a component or around a circuit. We normally think of current as flowing from positive to negative. Your students may find it easier to think of a current as a flow of electrons in wires, in which case the flow is from negative to positive because electrons are negatively charged.
- When using an ammeter, emphasize that it is necessary to break into the circuit to install the meter, so that the current flows through the meter.
- Always refer to the voltage *between* two points in a circuit, or *across* a component. You may prefer to refer to voltage difference or potential difference, since the word difference implies that we are considering two points.
- When using a voltmeter, connect up a complete circuit first and then add the meter. Emphasize that it has two leads, and that these are connected to the two points between which you wish you measure the voltage.

Electrical resistance

We need to be careful about the equation $V = IR$. Although this is often referred to as 'the Ohm's law equation', this is not strictly true. If we rearrange the equation as follows:

$R = V/I$

we can see its true meaning: it is the definition of electrical resistance. We can use this equation to calculate the resistance of a component, given the voltage across it and the current flowing through it.

So what is Ohm's law? We say that an object obeys Ohm's law if the current flowing through it is proportional to the voltage across it. In the form of an equation:

$I \propto V$, or

V/I = constant, or

R = constant.

This relationship applies only to certain components (usually resistors). A filament lamp does not obey Ohm's law (it is non-ohmic), but the equation $V = IR$ still applies if we want to calculate the voltage, for example, at any *particular* value of the current.

Series and parallel circuits

Topic 13.5 will help to reinforce students' understanding of the difference between current and voltage as they will have to think carefully about currents dividing up and recombining, and the way in which voltages are divided (shared) between components of a circuit.

Static electricity and magnetism

Historically, people imagined that static electricity and magnetism were closely related phenomena. In the 17th and 18th centuries, people experimented with amber and lodestone, which they regarded as the archetypal electrical and magnetic materials, and explored the attractive and repulsive forces that they produced.

The two phenomena are linked at a fundamental level. However, it is preferable to separate them in our students' minds, so you may wish to teach these two topics at different points in the curriculum. Some teachers prefer to deal with static electricity before considering electric circuits. Although this can give students a good idea of the nature of electric charge, some students find this approach rather abstract because it deals with phenomena that are largely observed in the laboratory rather than in everyday life.

Activity 'Wiring a three-pin plug' (Book 2, page 148)

Make sure that the practice plug has been 'damaged' in such a way that pupils cannot plug it into a socket. For example, bend the pins.

5 ICT resources for teaching science

Using ICT

Internet and computing technology (ICT) has many uses in science teaching. Here we give some guidelines on deciding what to use. The main rule is to use ICT resources that add something to your teaching – in other words, resources which do something desirable that you cannot do by some other means.

Many things, for example dealing with individual student's misconceptions, are better dealt with by the teacher themselves than by using ICT. Often, by asking a student questions, you can tease out what it is they have in their minds, and how you can attempt to change this.

Don't forget that books and other print materials have many advantages. It is easy to turn pages and scan text for points of interest. Students can take books home. Many websites attempt to reproduce textbooks, but this is not really making good use of ICT.

There is no doubt that the internet is a valuable resource, but it must be used wisely.

- **Before you direct students to a website, it is vital to check that it does not contain links to inappropriate sites.**
- **Check the source of the information on a website. Be alert to bias in the text and presentation of the information.**
- **Check the website each time you plan to use it – websites change frequently and can become out of date or the address may have changed.**

ICT resources, such as websites, multimedia CD-ROMs, hardware such as data loggers and sensors, and software such as spreadsheet programs, can do many things that you cannot easily do yourself. Such resources are particularly useful for showing things that are too small or too big, or too fast or too slow to show by normal experimental work – some examples are given in Table 4.

ICT simulations can also be used to show underlying concepts. For example, we cannot see forces directly, but we can represent them by arrows and show how they change when an object moves.

Table 4 Examples of situations when ICT is a useful tool to teaching

Too small	Atoms are too small to see, but we can simulate them on a computer, and show how they move. This can be useful for showing the differences between solids, liquids and gases (as well as lots of chemical changes).
Too big	The solar system is big, but it can be modelled using software.
Too fast	Falling objects move too fast for the detail of their motion to be seen clearly. (You may have used ticker timers to enable analysis of this motion.) Light gates and data loggers can record a moving object, or the object can be filmed with a video camera. Then the data collected can be analysed by computer.
Too slow	You can record changes that take place over hours or days using ICT, for example, changes in temperature and light level, which can then be displayed graphically so that students can look for correlations.

General ICT resources

- Multimedia Science School, published by New Media (**www.new-media.co.uk**), is an ever-growing collection of interactive computer models. Worksheets are also included.
- Granada Learning Ltd (**www.granada-learning.com**) publishes an array of teaching materials, including activity sheets, lesson ideas and CD-ROMs.
- **www.schoolscience.co.uk** is a free website which specializes in developing resources linking all aspects of school science to its applications and implications in industry. It includes links to many other sites of interest.
- The Museum of Science, Art, and Human Perception has an interesting site (**www.exploratorium.edu**) that covers a diverse range of subjects including species diversity, fire and astronomy. It also includes links to other sites.
- **www.howstuffworks.com** covers a huge range of science subjects and includes links to many other sites.
- **www.adprima**.com gives many useful teaching tips, including lesson plans.
- **www.askeric.org/Virtual/Lessons/** contains sample lessons.

ICT resources for teaching physics

- Astronomy, a multimedia CD-ROM published by Granada Learning Ltd (**www.granada-learning.com**), includes a series of documentary-style animations with commentary. The teacher can select a programme of relevant clips for students to study.

- Crocodile Clips (**www.crocodile-clips.com**) is a commercial site producing software for science education. As its name suggests, it started with programs dealing with electric circuits, but it has branched out into other fields. Sample software is available on the site.
- The Royal Greenwich Observatory has an extensive site (**www.rog.nmm.ac.uk**) which includes a tour of the solar system.
- The UK Particle Physics and Astronomy Research Council will supply free copies of wallcharts, leaflets etc. Contact them via their website (**www.pparc.ac.uk**).
- The University of Oregon has a useful site with information about energy resources (**www.zebu.uoregon.edu/energy.html**), including renewables, plus links to many other energy sites.
- The Institute of Physics will answer students' questions about physics (and your own) at www.physics.org.

ICT resources for teaching biology

- **www.cdc.gov/** is the website for the US Center for Disease Control and Prevention. It contains useful information on many diseases, health topics and statistics.
- **science.nhmccd.edu/biol/animatio.htm** contains useful animations of the major body systems.
- The British Broadcasting Corporation website (**www.bbc.co.uk**) includes a range of information on current environmental and scientific issues.
- **netvet.wustl.edu/ssi.htm** is the Electronic Zoo. The site contains many links to related websites providing information about many different animals.
- **www.ran.org/kids/action** is the Rainforest Action Network, which has useful information on sustainable development issues.
- **www.innerbody.com** provides a range of views of the human body.
- Information about the Human Genome Project is provided by the US National Human Genome Research Institute at **www.nhgri.nih.gov**. A student guide to the Human Genome Project can be found at **www.ornl.gov/hgmis/education/students.html**.
- The National Centre for Biotechnology Education (**www.ncbe.reading.ac.uk**) site covers many aspects of biotechnology. It includes practical activities that you could incorporate into your teaching.
- The UK Biotechnology and Biological Sciences Research Council (**www.bbsrc.ac.uk**), Natural Environmental Research Council (**www.nerc.ac.uk**) and Medical Research Council (**www.mrc.ac.uk**) can provide a range of up-to-date educational

resources, many of which can be downloaded directly from their websites.

ICT resources for teaching chemistry

- **schoolscience.co.uk** has an excellent electronic periodic table of the elements.
- Multimedia Chemistry School, published by New Media (**www.new-media.co.uk**), is an ever-growing collection of interactive computer models. Worksheets are also included.
- Aluminium production, including environmental aspects, is described at **www.world-aluminium.org**.
- Oil and gas formation and extraction are presented in a simple way at **www.petroleum.co.uk/discover**.

6 Answers to questions

Book 1

Unit 1: Being a scientist

Multiple choice

1 B **2** C **3** FALSE **4** FALSE

5 TRUE **6** TRUE

Short answers

1 One can work safely and obtain good-quality results.

2 To obtain accurate results by using the most suitable scale.

3 The senses make us aware of our surroundings and allow us to respond to stimuli.

4 The process that scientists use when doing their investigations and experiments.

Unit 2: Looking at life

Multiple choice

1 B **2** B **3** A **4** B **5** A **6** D

7 A **8** B **9** A **10** C

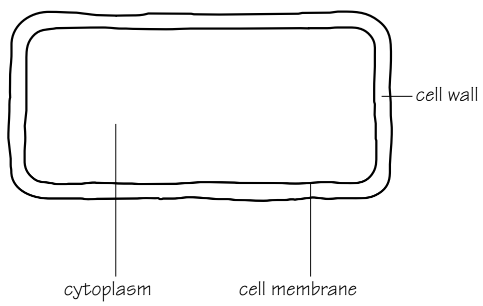
Short answers

1 The nucleus controls the activities of the cell.

2 Each person has his/her own pattern of DNA, and this can be used for identification.

3 A group of tissues performing a function.

4



5 A virus is not considered to be a living thing because it is not capable of independent existence – it requires other living cells to reproduce.

6 Classification is a process of sorting things. It allows information to be obtained quickly and easily. Predictions can also be made easily.

7 Fish, amphibians, reptiles, birds, mammals.

8 It lacks a backbone.

Unit 3: Water

Multiple choice

1 B **2** D

Short answers

1 Some substances dissolve easily in water.

2 It can carry dissolved chemicals and disease-causing organisms that may harm or kill organisms in the ecosystem, upsetting its balance.

Unit 4: Energy

Multiple choice

1 B **2** C **3** B **4** C **5** A **6** B

7 D **8** C **9** A

Short answers

1 Uranium is used as the **fuel**.

The **reactor** produces hot steam.

The steam causes the **turbine** to spin round.

This also makes the **generator** turn.

Electricity flows in the **cables**.

2 a Energy is the capacity to do work. It is measured in joules (J).

b A fuel is a substance that releases energy when burned. Oxygen is needed.

c Less carbon dioxide means less global warming and climate change; less pollutants released means less acid rain.

Unit 5: Systems in plants

Multiple choice

1 D **2** B **3** A **4** D **5** A **6** A

7 D **8** A

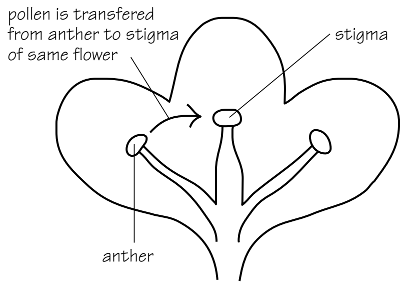
Short answers

1 Fruits and seeds can be dispersed by animals, wind, water and by self dispersal.

2 In photosynthesis carbon dioxide is taken in and used to make plant food containing energy, and oxygen is given off. Respiration uses oxygen to release energy from food, and carbon dioxide is given off.

3 The boiling point of methylated spirits is low, about 70°C and it can easily burst into flames.

4



5 The **seeds** are formed when two **sex cells**, the **male** and **female**, join. The young plant gets its **food** from the **cotyledons**. The young **seedling** grows as the **radicle** bursts through the **testa** or seed coat.

Unit 6: Heat and its effects

Multiple choice

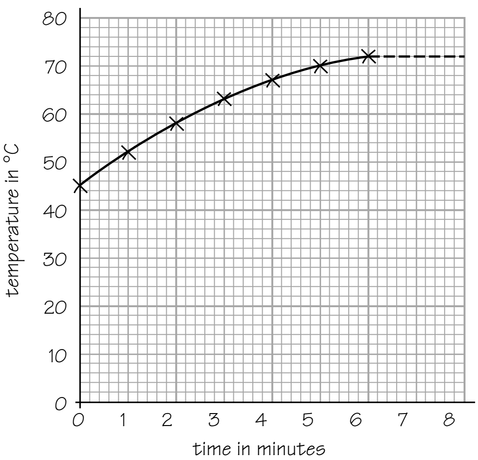
1 D **2** D

Short answers

1 A 0°C B 37°C C 100°C

2 Liquid-in-glass thermometer

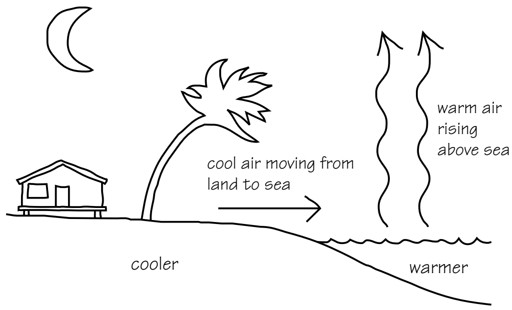
3 a



b Because it had reached melting point. (Beyond 6 minutes the temperature stays at 72°C.)

c Energy escapes more quickly the temperature of the wax rises above room temperature.

4



Unit 7: Looking after your health

Multiple choice

1 C **2** B **3** C **4** C **5** D

6 i and iii are correct

Short answers

1 Persons who are allergic to certain drugs especially aspirin and penicillin, wear medical identification bracelets so that if they are hurt they are not treated with these drugs. People with have conditions such as diabetes also wear such bracelets to provide information if they are found unconscious

2 Artificial respiration is a way of helping a person to breathe when their breathing has stopped.

3 An allergic reaction is when the body reacts badly to something in the environment such as dust, pollen or drugs.

4 Fish can be preserved by drying, freezing and smoking.

5 Because drinking water often becomes contaminated by the bacteria that cause gastroenteritis.

6 Milk, for example, is heated to about 70°C for about 15 seconds.

7 If meat and poultry are undercooked, harmful organisms will not be killed and may cause food poisoning.

Unit 8: The Universe

Multiple choice

1 C **2** B **3** D **4** C **5** A and D

Short answers

1 Elliptical, almost circular, in a flat plane.

2 300 000 000 m/s

3 The Moon

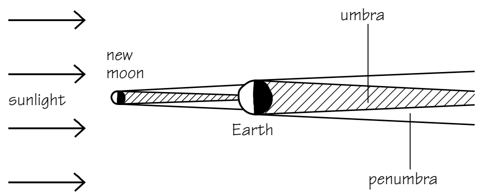
4 Distances (to stars, galaxies etc.)

5 The Milky Way; a spiral (with two arms).

6 Rocky: Mercury, Venus, Earth, Mars. Gas giants: Jupiter, Saturn.

7 Lump of rock; between orbits of Mars and Jupiter.

8 a Eclipse of the Sun.
b



9 a The pull of the Earth's gravity
b Causes tides

10 Cold (–270°C); it has cooled down.

Book 2

Unit 9: Looking at non-living things

Multiple choice

1 B **2** A **3** B **4** D **5** D **6** A
7 D **8** B

Short answers

1 The three states of matter are solid, liquid and gas.

2 a P – gas; Q – liquid; R – gas; S – liquid; T – liquid U – solid
b S and T
c Q and S
d P is a gas: particles are far apart, moving randomly; S is a liquid; particles are jumbled close together but can slide past one another; U is a solid: particles are close together, in fixed positions.

3 The solvent is the liquid in which a substance dissolves. Examples are water, paraffin, turpentine, acetone, white spirit, etc.

Unit 10: Resources for life

Multiple choice

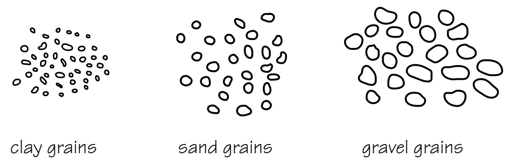
1 C **2** C **3** C **4** A **5** C

Short answers

1 Oxygen, carbon dioxide, nitrogen, water vapour and the noble gases.

2 Oxygen

3



4 Soil is formed from the break down of rocks, volcanoes and the death and decay of organic material. Soil is lost through wind action, action of water and actions of people.

5 a A carnivore is an organism that eats only flesh.
b A consumer is an organism that takes in food.
c An omnivore is an organism that eats both plant material and flesh.
d A producer is an organism that makes its own food i.e. the green plants.

6 The Sun

7 The food chain must begin with a green plant and should not be longer than five links. Examples are: plant → mouse → snake; plant → insect → small bird → hawk

Unit 11: Systems in animals

Multiple choice

1 B **2** A **3** C **4** D

Short answers

1 Mouth → oesophagus → stomach → duodenum → small intestine.

2 To strengthen the tooth and prevent decay and cavities.

3 Because the cholesterol can be deposited on the walls of blood vessels and cause a blockage of the blood vessels, which can lead to a heart attack.

4 To take food, oxygen and other substances to the cells of the body, and to remove waste and other harmful substances from the cells to points where they could be got rid of.

5 Pulmonary vein and aorta.

6 The heart is responsible for pumping blood around all of the body.

7 Doctors prescribe drugs to treat particular illnesses. The drug may harmful effects on someone who does not have the illness for which the drug is prescribed.

Unit 12: Support and movement

Multiple choice

1 D **2** A **3** B **4** A **5** B **6** A

Short answers

1 To seek food, shelter and a mate.

2 Muscles, tendons, bones and ligaments.

3 Hinge joint – elbow, knee; ball-and-socket joint – hip, shoulder; gliding joints – wrist.

4 Lactic acid builds up during exercise, which causes muscle fatigue. The oxygen debt is the amount of oxygen needed to get rid of this lactic acid build up.

Unit 13: Electricity and magnetism

Multiple choice

1 D **2** C **3** C **4** B **5** A **6** B

7 D

Short answers

1 Two or more cells in series make a battery.

2 Sunlight (solar radiation)

3 2 Ω

4 Volume control on radio; lighting dimmer switch; theatre lighting control; speed control on motor; etc.

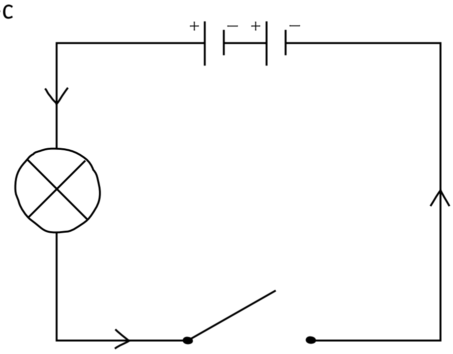
5 30 Ω

6 6 V

7 It has zero net charge; equal amounts of positive and negative charge.

8 The Earth has a south magnetic pole near to its North geographical pole; this attracts the magnet's north pole.

9 a–c



d When the switch is open, there is no complete circuit for current to flow through.

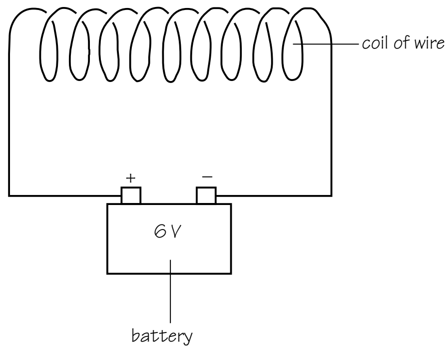
10 a 120 Units
b Cost = $30; she was overcharged.

11 a In parallel
b Current through B is greater, because its resistance is less and they have same voltage across them.
c Current would stay the same, because the voltage across A would not change.

12 a Positive
b Friction
c Electrons (from cloth to plastic)
d Plastic has gained electrons
e Attract

13 a 0.1 A b 0.2 A c 100 V

14 a



b More turns of wire; turns closer together; more current; iron core

c Can be switched on and off

d Electric bell; relay; door lock; in scrap yard; trip switches; etc.

Book 3

Unit 14: The Earth

Multiple choice

1 C **2** D **3** C **4** A **5** C **6** A **7** A

Short answers

1 Iron, nickel

2 Extraction of useful minerals; rich soil for growing crops; hot springs as energy source.

3 Richter scale

4 Seismograph

5 Seal a syringe or bicycle pump and compress it. Inflate car tyre.

6 Silicon and oxygen

7 a Barometer
b Strong
c Friction
d It will be reduced

8 a They react to produce oxides and other compounds
b A mineral from which a metal can be extracted
c Carbon dioxide
d Smelting
e Bauxite
f Electrolysis
g Cryolite

Unit 15: Light and sound

Multiple choice

1 C **2** B **3** A **4** B **5** B **6** A

Short answers

1 Concave lens magnify objects.

2 A pinhole camera gives an image that is **upside down** and **reversed**. A large pinhole gives a **bright** but **fuzzy** image. A **small** pinhole gives a **less bright** but **sharp** image. The **image** in a pinhole camera can be photographed. This is referred to as a **real** image.

3 Refraction is the bending of light when it moves from one substance to another.

4 Camera, magnifying glass, spectacles, contact lenses.

5 Binocular vision allows us to judge distances by seeing with two eyes.

6 Accommodation is the process by which the eye adjusts to focus on different objects.

7 Ultrasound can be used for cleaning objects and materials; to detect weaknesses in metals and other materials; in medicine to look inside the human body.

8 Sound is caused by vibration in an object. Noise is very loud unwanted sound or a sound that has a random jumble of frequencies.

Unit 16: Systems in humans

Multiple choice

1 B **2** A **3** C **4** D

Short answers

1 a Adrenal glands
b Pancreas
c Thyroid
d Pituitary

2 To keep the sperm cells at a temperature lower than body temperature.

3 No

4 By the placenta and umbilical cord

5 Two eggs are released from at the same time and both are fertilized.

6 By diffusion in the umbilical cord, from the mother's blood vessel into the embryo's blood vessel.

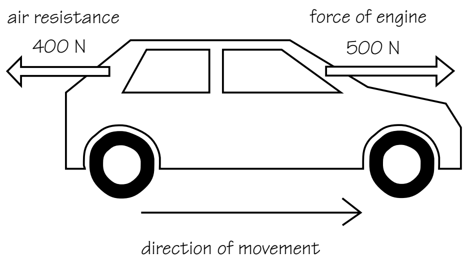
Unit 17: Forces

Multiple choice

1 B **2** C **3** C **4** C **5** D **6** B
7 D **8** C **9** A **10** B

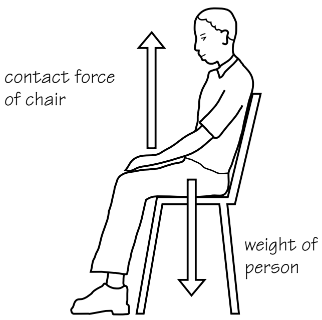
Short answers

1. Isaac Newton
2. Speed, direction, shape
3. An object remains at rest or continues to move at a steady speed in a straight line (i.e. with uniform motion) unless acted on by an unbalanced force.
4. 200 N
5. Scissors, seesaw, tyre lever
6. 200 W
7. a



   b No, unbalanced
   c t will speed up (accelerate).
   d Unbalanced force now backwards, so car decelerates.

8. a



   b Reaction
   c They are equal.
   d Balanced

9. a Yes – force = 0.5 m × 90 N = 45 N, which is greater than 200 N × 0.2 m
   b No – the force of the load would be 250 N × 0.2 m = 50 N, which is more than the force provided by the lever.

Unit 18: The environment and its maintenance

Multiple choice

1 A **2** D **3** C **4** A **5** C **6** A

Short answers

1. Any three from: leather back turtle, Pawi bird, the West Indian whistling duck, the Nassau grouper, the red necked Amazonian parrot, the golden macaw.
2. Fertilizers and pesticides can contaminate soil water.
3. By dumping their faecal waste into the water and by dumping non-biodegradable waste into the sea.
4. Sewage-contaminated water contains disease-causing micro-organisms such as bacteria that cause cholera and dysentery.
5. Mercury and lead.
6. Biodegradable materials can be decomposed by bacteria and fungi in the environment.
7. Re-planting of trees in the environment prevent land slides and loss of soil, and slow water run off, thus preventing flooding.