# Convenio M.E.C./British Council

**Orientaciones pedagógicas para el desarrollo del Currículo Integrado en el nivel de Educación Secundaria (4º E.S.O.):**
**Ciencias Naturales : Biología y Geología**

**Guidelines for the development of the Integrated Curriculum in Secondary Education (4º E.S.O.):**
**Biology and Geology**

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## Introduction to the Biology / Geology Curriculum

This Integrated Biology/ Geology Curriculum for E.S.O. 4º is based on the new (2007) Spanish curriculum and the current British curriculum.

E.S.O. 4º introduces the main biological and geological theories that determine the present perspectives of both disciplines. Throughout the geology section, the students learn about the Earth's geological history and activity, and how this is related to the plate tectonics. The biology section deals with the theory of evolution and inheritance, with all its social applications and implications. As to the ecology section, the emphasis is put on the interrelations between living beings and their environment, relating this to the main environmental issues.

The order of teaching topics may be changed to allow the pupils to use an English textbook and to work within topic areas. The QCA (Qualification & Curriculum Authority), Department for Education and Skills (DfES) has recently published a programme of study and science criteria for Key Stage 4 including preparation for the GCSE science exams. These documents, available from the QCA website (see appendix) may prove useful to teachers when planning units of work.

### Methodology

- A major aim of this Integrated Curriculum is to encourage an imaginative approach to the teaching of Biology and Geology. Not only do our pupils need to learn scientific facts but also, increasingly, they need to be able to use and apply their scientific knowledge.
- Pupils need to be encouraged or challenged to reflect upon scientific interpretations: Where did the information come from? How do we know it is true? How can I check on it? They also need to understand how scientific ideas are developed, and they need to be able to plan and carry out scientific investigations to test out ideas experimentally. In doing this they will be developing their practical skills, learning how to solve problems, learning how to evaluate their results and thus be able to evaluate the scientific information which they will be coming in to contact with on a daily basis throughout their lives. Current concerns which could affect all of us include genetic engineering, bioethical issues, climate change, endangered species or sustainable development. Pupils need to be able to evaluate the importance and relevance of these complex science-based topics for themselves. This curriculum aims to give pupils experience of many types of scientific enquiry such as:
    - recognising patterns and correlations.
    - using first hand and second hand sources of information including ICT.
    - identification and classification techniques.
    - how to use and evaluate some scientific techniques or applications.
    - the need for fair tests involving controls.
    - using experimental models and analogies.

**The use of practical work**

As well as teaching Biology and Geology, the course also specifies which science skills should be taught. Teaching science skills is as important as teaching the contents.

- Practical skills work can be used for a number of reasons such as:
  - To back up theory work.
  - To give the pupils first hand experience.
  - To learn how to carry out a scientific investigation.
  - To develop science skills.
  - To stimulate the pupils' interest.

- Teachers will use a variety of different approaches to practical work with their pupils which may include the following if appropriate:

  - ✓ Starting a topic with an investigation to allow the pupils to find out some of the key concepts through their own work. In practice this cannot be used too often as it can be time consuming and it must be carefully structured to allow the pupils to be led in the right direction.
  - ✓ Using practical work to illustrate a concept. The teacher will have already introduced the main points and questioned the pupils to assess their basic understanding, and then structured practical work will be used to reinforce the theory.
  - ✓ Practical demonstrations by the teacher so that the results can be discussed at the time.
  - ✓ Small practical activities during a theory lesson to break it up and to introduce new ideas and points for discussion.

- Practical work need not use a lot of equipment nor a lot of time and it may vary from:

  Full investigations such as:
  - A biology field trip lasting a whole day.
  - Observation of mitosis in root tips.

  Shorter practical investigations such as:
  - An investigation to observe the process of natural selection.
  - Making fossils.
  - The extraction of DNA from strawberries.

Or quick activities such as:
- Demonstrating the movement of tectonic plates using plasticene.
- Observing crystal formation in different environments.
- Investigating the dynamic model of the earth.

**Different approaches to teaching and learning**

All pupils do not learn in the same way, so it is important to give them a range of different kinds of experiences to give them the opportunity to develop. The range of types of experience can be summarised as:

| Type of experience | Examples of possible activities | |
|---|---|---|
| | **Used by pupils** | **Used in teaching** |
| **Visual** | PowerPoint slides, making videos, making a poster, use colour codes for revision, mind maps, making graphs, key diagrams, computer based learning. | PowerPoint slides.<br>Posters on the walls.<br>Video.<br>Internet searches.<br>Practical demonstrations.<br>Visits to museums and planetariums. |
| **Audio and linguistic** | Word puzzles, writing a magazine article, crosswords, discussion, debates, comprehension tests, library search, presentations from/to the class<br>Listening to a news/documentary report. | Word walls.<br>Setting library or newspaper search investigations.<br>Internet/TV news/documentaries/reports.<br>School magazine.<br>Entering national science competitions. |
| **Kinaesthetic, physical** | Model making, practical tasks, role-play, making flash cards and posters. Movement. | Hands-on practical lessons.<br>Using role-play to act out ethical dilemmas. |
| **Mathematical** | Organising tasks into steps, listing key points, making tables and graphs of information, making timelines, creating flow charts. | Preparing quantitative practical lessons to generate data.<br>Using flow charts to sequence an activity.<br>Using Excel for dealing with data tables and graphs. |

These types of experiences above should be taken into account when preparing the scheme of work to ensure a good range of different activities. This does not mean that there is no place for the normal class where the teacher stands at the front and delivers a lesson. On the contrary, the teacher has an even more central role in ensuring that all the pupils are given the best opportunity possible to understand the concepts and take an active part in their own learning. Rather than lecturing to the pupils, the teacher has to be looking for feedback and response, by questioning the pupils, testing them to see if they understand.
When carrying out practical activities pupils will usually be working in groups. This is an important part of learning how to work together and supporting each other within the team.

**Assessment of practical work**
The teacher will assess different aspects of practical work. The main areas are:

| Area | Skills to be taught | *Examples of opportunities for teaching the skills* |
|---|---|---|
| **Ideas and Evidence** | Making predictions, looking at how scientists worked in the past, considering evidence and scientific explanations. | Mendel's law of segregation and the outcome of genetic crosses.<br>The theory of plate tectonics.<br>The acceptance of Darwin's theory of natural selection. |
| **Obtaining and presenting information** | Collecting data, using tables, bar charts and graphs, using ICT formats of presentation to include written summaries extended writing and short talks using power-point presentations. | Making charts, tables, graphs to compare investigation results.<br>Making calculations including, percentages, averages, ratios etc.<br>Classifying, e.g.: The types of mountain ranges<br>Describing some of the factors, which affect the population of a species?<br>Describing the different theories of evolution |
| **Considering results** | Drawing conclusions, explaining using scientific knowledge and understanding<br>Considering the power and limitations of science in addressing industrial, social and environmental questions, including the kind of questions science cannot answer.<br>Looking at uncertainties in scientific knowledge and the ethical questions involved. | Recognising that DNA and hence genes control some of our characteristics<br>Commenting on the purpose, approach and suitability of a given experiment.<br>Commenting on the limitations of the set up, apparatus, suggested measurements or observations, limitations of equipment and appropriateness of controls.<br>Studying the reasons causing species to become endangered. |
| **Evaluating results** | Accuracy of the results, how investigations can be improved<br>These aspects of evaluation should be kept in mind when planning a scheme of work. | Commenting on sources and causes of error.<br>Suggesting possible improvements in method. |

## Text books

In the Integrated Curriculum, at this level, Biology and Geology are taught in English. The topic order is flexible and can be adapted to the chosen textbook and the supplementary material available.
This course is designed so teachers can choose textbooks in English as appropriate for their pupils. As the Integrated Curriculum is designed to cover the Spanish and English objectives, there is no “ideal” textbook. However, given the methodological approach, many teachers may find an English textbook to be more appropriate.

The British system has 5 years of secondary education from year 7 to year 11; the equivalents of these in the Spanish system are:

| | | |
|---|---|---|
| Y7 | 6º Primaria | Key Stage 3 |
| Y8 | 1º ESO | Key Stage 3 |
| Y9 | 2º ESO | Key Stage 3 |
| Y10 | 3º ESO | Key Stage 4 |
| Y11 | 4º ESO | Key Stage 4 |

Y10 to Y11 are called Key Stage 4 and are taught a two-year course in preparation for GSCE examinations. Different examination boards exist with slightly different requirements for the exams that they set. The textbooks below reflect those differences and therefore more than one option is provided.

## Suggested textbooks for teaching the curriculum for 4º ESO are:

N.B: The textbooks in the first section are **general science** course books, including all of the biology topics and with some useful material connected to the geology topics.
They are useful both for students intending to work towards the IGCSE exam and those who do not intend to take the exam.

| | | | |
|---|---|---|---|
| **AQA GCSE Science Core Foundation** | | Hodder Murray | ISBN 0-340-90708-8 |
| | Teachers' Guide | | ISBN 0-340-91418-1 |

Further information available at: -www.gcsescience06.co.uk/AQA/AQA1.htm

| | | | |
|---|---|---|---|
| **Science Plus** | Book 1: | Collins | ISBN 0-00-721648-3 |
| | Book 2: | | ISBN 0-00-721649-1 |
| | Teachers guide and CDROM | | ISBN 0-00-721650-5 |
| | Homework and assessment on-line | | ISBN 0-00-721645-9 |

Further information available at: - www.collinseducation.com

## Biology Textbooks

The following text books are specific Biology courses and are considered particularly useful for students who intend to work towards the Biology IGCSE exam.

**Cambridge IGCSE Biology** Collins ISBN 0-00-775542-2
**Revision Guide Biology** Collins ISBN 0-00-719058-1
Further information available at: - www.collinseducation.com

**BIOLOGY *first*** (OUP) ISBN 0-19-914731-0
Further information available at: www.oup.com

## Geology text books

Geology is not widely taught in the United Kingdom at GCSE level so there is no single textbook, but there are a variety of books available covering aspects of the subject.

**Understanding Geology** David Webster Oliver & Boyd ISBN-13: 978-0-05-003664-8
Simply illustrated with diagrams in black and white, could act as a textbook. This book also covers the content of the ESO3 Geology course

The following books have useful chapters and can provide supplemental reading or act as a partial textbook.
**A Short History of Planet Earth** J.D. MacDougall Wiley ISBN 0-471-19703-3
A good contender as a substitute for a text book.

**Geology** – A Self Teaching Guide Barbara Murck Wiley ISBN 0-471-38590-5
Includes quizzes and self tests

**Earth Science** Homework Helpers Phil Medina Career Press ISBN 1-56414-767-3
Could be used to set questions for homework or tests by the teacher

**Science 4: Biology and Geology** Santillana ISBN 84-294-7827-2

**The Practical Geologist** Dougal Dixon Simon & Schuster ISBN0-671-74697-9

**Introducing Geology**, a Guide to the World of Rocks Graham Park Dunedin Academic Press ISBN 1-903765-64-1

**From the Beginning** Katie Edwards and Brian Rosen Natural History Museum ISBN 0-565-09142-5
This book was written to complement the “From the Beginning” exhibition in the Earth Galleries at the Natural History Museum, London. It does not contain exercises or questions to answer but has an appropriate reading level and can be used for supplementary reading or research.

More details or order from www.nhmshop.co.uk, NBN International or Amazon

## Literacy Links

Throughout the document references are made to links with Literacy, which may include newspaper articles, biographies and other materials from the Internet. In addition, teachers may find some fictional materials that provide starting points for discussion, illustrations of concerns about new techniques or projections of future developments. Some novels that might provide excerpts for study in class or by the students at this level are listed below.

**Horrible Histories Series**
**Horrible Science Series**

**The Cell** by Steven King

**Jurassic Park** by Michael Crichton
**Prey** by Michael Crichton

**His Dark Materials** Philip Pullman

There are further sources of ideas for reading materials at the following websites.

**National Science Week Fiction Booklist** for children & young people of all ages.
This can be found under the resources section on the website of the British Association for the Advancement of Science www.the-ba.net. The list is compiled by the London Borough of Tower Hamlets Children's Library Service.

**The Best Book Guide for Children and Young Adults**, formerly known as 100 Best Books. Guide produced annually by Booktrust, featuring a selection of the best new paperback fiction for all ages, from babies to teenagers, across a variety of writing styles and subjects. £5.
Contact: Book trust, Book House, 45 East Hill, London SW18 2QZ. Tel: 020 8516 2977. Website: www.booktrust.org.uk.

**British Literature For Young People**: a Bibliography 1990 - 2000, selected by Julia Ecclesiae, The Guardian children's book editor, is a list of the best books of the decade with details of children's book prizes and magazines promoting children's literature. £4.99.
Contact: British Council on 020 7389 3170 or visit www.britishcouncil.org/publications.

Other links can be found at: - www.literacytrust.org.uk/familyreading/parents/books.html

## THE SCIENCE CURRICULUM

The curriculum for 4º ESO is divided into three main sections:

- Geology
- Genetics and Evolution
- Ecology

This curriculum is meant as a practical guideline that each teacher can adapt according to the pupils' needs, available time, school resources, etc. Each of the sections is split up into a suggested teaching sequence which should be followed as some concepts need to be introduced before others.

The introduction to each section includes the titles of the section and the areas to be covered. There is also a section on assumed knowledge, which summarises the sections of the syllabus already covered in previous years. This could be used to introduce the section to the pupils by finding out what they already know. It could be done using a quick quiz. It is important to realize that the pupils will already have a great deal of scientific knowledge and understanding; we have to find out how much and then build on this foundation.

Some symbols and abbreviations used throughout the curriculum are:

**h** The suggested time of the lesson or lessons, usually 1 or 2 hours.
In the same column there is also information as to the importance of the lesson:

- Core: means it is an essential part of this Integrated Curriculum.
- Revision: means that if necessary, it may be included before proceeding with the topic.
- Extension: means if you have time you might like to do it but it is included to provide more practice in or depth to a topic.
- Investigation: means a practical activity, which may form part of the core.

**Lesson outline**: This is not a lesson plan but there are suggestions for activities to be carried out in the lesson.

**Assessment activities**: These are suggestions for assessment opportunities that may come up in each lesson, as well as activities which may be used in each lesson. Teachers are advised to select those they consider most appropriate to their needs and the needs of their students.

**Lesson outcomes**: An outline of the learning expectations for pupils from that lesson.

**Resources**: Suggestions for useful resources which are needed or would be useful for that lesson. These include both references to the suggested texts and websites.

**N.B**: Suggestions have also been made where appropriate of how teachers can link to other curricular areas. These are indicated using the following key:

**LL**: Literacy link (some of the activities which involve report writing etc could be carried out in a literacy class).
**GL**: Geography link (some of the content may also be covered, from a different perspective, in the Geography curriculum).
**CL**: Chemistry link (some of the content may also be relevant to areas of Chemistry).
**HL**: History link (some of the content may also be connected with work covered in a History lesson).
**NL**: Numeric link (some of the content may be relevant to areas of Mathematics).
**CiL**: Citizenship link (some of the content may be related to topics of Citizenship).

# Biology

## Topic: The Evolution of Life

### Assumed knowledge

The cell in plants and animals, from ESO1, its basic structure and main organelles.
The arrangement of higher plants and animals into tissues, organs and organ systems.
The seven common features of living organisms, especially growth and reproduction.
Some general knowledge of cellular functions and enzyme activity.

### Content of this module

1 The cell as the unit of life, its importance in Biology as a structural and functional basis of living organisms. How understanding of the cell is used to underpin interpretation of the form and function of living organisms.
2 The nucleus contains chromosomes that carry the genes.
3 Cell division through mitosis and meiosis, the differences between these processes and their individual importance to living organisms.
4 The composition, structure and properties of DNA. The importance of the discovery to subsequent development of biological sciences.
5 The different levels of organisation of living organisms from unicellular to multicultural, and exploration of these through the microscope.

Time for this module, 4 lessons, approximately 4-6 hours, and 2 extension activities approx 2 hours.

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
|---|---|---|---|---|
| 1 Core | Cell structure and organisation<br><br>Revise the content of Cells (ESO1) (Revision could be through quiz or pursuit cards) and compare a typical plant leaf cell with an animal cell, for the basic organisation, naming the main components or organelles and defining their function.<br>Compare those functions common to both and those which are different. Relate the activities within the cell to the characteristics of life. Compare unicellular organisms such as yeast and amoeba with bacteria. Describe the differences between eukaryote and prokaryote cells.<br><br>Use can be made of projected slides of cell organelles seen by optical or electron microscope or examples under microscopes in the class. Comparison to diagrams in textbooks shows how details are simplified for clarity and do not portray reality. The greater degree of detail may lead to extending vocabulary to include to endoplasmic reticulum, ribosome, lysosome, nucleolus, Golgi body, etc<br>The students can produce their own drawings and definitions of each organelle and its function. | Labelling diagrams with cell components.<br><br>Making glossaries of terms used. Matching terms underlined to definitions given. Correcting errors in definitions provided by the teacher.<br><br>Preparing charts comparing similarities and differences of cells from the five kingdoms.<br><br>Making a model cell in a box or bag to represent plant cell or animal cell. | Students recall the main features of a variety of cells, and can distinguish between those from different kingdoms.<br><br>They can list the seven characteristics of living organisms<br><br>They can use a microscope and drawings of cells or electron micrographs to identify organelles. | Slides / photographs of different cells showing organelles or samples under microscopes, e.g. plant palisade cells, liver cells, yeast, etc.<br>Examples of cells seen by electron microscope. e.g. http://www.microbeworld.org/resources/educate.aspx http://www.denniskunkel.com/DK/DK/Medical/<br><br>Quiz / pursuit cards e.g. "I have no nuclear membrane….etc. What am I?" "You are a …"<br><br>Collins IGCSE Biology chapter 1. |

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| 1 Extension | <u>Practical use of microscope and preparation of biological material.</u><br><br>Prepare the epidermis of an onion from inside its bulb by mounting on a microscope slide in a drop of water and covering with a coverslip before viewing the regular pattern of cells under a microscope.<br>This will provide practice in manipulating biological material, using a variety of simple apparatus and techniques which can be applied to other lessons. A simple stain using iodine can be applied. With care very thin slices of cucumber or celery can be made and examined. What is different in these cells to other plant cells? These observations also demonstrate why thought cells resembled tiny rooms.<br>Actively growing yeast cultures can be smeared on a slide and examined.<br>Smear preparations of cells from the inside of the human cheek may be permissible but local guidance on safety procedures should be sought. | Write instructions for someone else to follow to carry out this procedure.<br><br>Draw what is observed under the microscope.<br><br>**HL/LL**<br>Students could read about the early development of microscopy. | Students can use simple techniques accurately and explain what they did using the appropriate vocabulary e.g. *<u>slide</u>, <u>coverslip, forceps</u>, <u>scalpel, dropper/pipette, mounted needle</u>*.<br>They can observe and draw what they see. | Microscopes, slides and coverslips, onions, instruments, iodine solution. |

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| 1 Core | <u>Levels of organisation</u><br><br>Revise the major systems, respiratory, digestive, nervous, etc, which organs are part of the system and which tissues form part of the organs. Revision of different types of tissues, comprising cells of the same type carrying out the same function. Relate to ESO3, eliciting examples from respiratory, excretory, nervous, digestive systems, etc. Compare some similar modifications in different organs, e.g. ciliated cells. How is the cell modified? Why is it necessary in each location? Look at unique modifications e.g. nerves, heart muscle, red blood cells. How are shape, size and function related?<br>Compare tissues from different sites and relate them to their function, what differences are there? E.g. epithelial cells from skin and parts of the digestive tract. Observe prepared slides stained to demonstrate features.<br>Analyse an organ to find out what tissues it is made up of. What purpose or function does each serve in the organ? E.g. epithelial cells provide a smooth surface for blood to flow through the heart.<br>Can groups of cells or tissues act independently? How are cells co-ordinated? Revise hormonal/endocrinal, voluntary and involuntary nervous and somatic co-ordination. | Match descriptions of cell type to name or tissue where it is found.<br><br>Complete charts showing what tissues are present in given organs.<br><br>Create a poster of an organ showing cut-away or enlargements revealing the tissues. | Students understand the level of organisation of living organisms, from cell to tissue to organ to organ system.<br><br>They can relate modifications of the basic cell type to the function of that cell type and also to its place in the organ or system.<br><br>They can analyse an organ to explain its function in terms of its structure and component tissues. | Activities prepared by the teacher, descriptions of cells types and tissues, blank or partially filled in charts. |

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| 1 Extension | <u>Cellular activity</u><br><br>Remind students about the need for nutrition, oxygen, removal of waste in the living organism and how living things respond to their environment to satisfy these needs, e.g. plants turn towards the light. Cells not only maintain themselves, they also grow.<br><br>Relate this to activities within the cell that use enzymes, e.g. metabolism or respiration. Set up demonstrations or arrange experiments using enzymes, such as amylase and starch at different temperatures as suggested in ESO3 digestion or yeast converting sugars to carbon dioxide.<br><br>Explain that scientists study of and understanding about enzymes helped to develop the study of activities within cells and how cells were able to grow and reproduce themselves. Enzymes release energy for cell activities, break down large molecules, and build new molecules as required. | Students follow instructions to observe the effects of enzymes on substrate such as starch.<br><br>Students carry out research into a number of enzymes and what their function is and write a brief description. | Students understand that enzymes are important to normal cell function, that cells contain enzymes that breakdown molecules and build new molecules or release energy within the cells. | Corn starch, amylase or students' saliva, suitable test tubes, reagents for testing for starch and glucose. |

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| 1-2 Core | Growth and the process of cellular division.<br><br>Ask the students to define growth as compared to inflating a balloon (the irreversible increase in dry mass of an organism is one possibility). How do we grow new skin over a wound or longer hair? How do organisms grow in size? How do they think cells grow in number? Explain role of the nucleus in more depth, illustrating the presence of chromosomes from slides. Explain the number of chromosomes varies with species. Some online sources show *Drosophila sp.* which has 4; others show human nuclei with 46 chromosomes.<br>Arrange for the students to prepare a squash preparation of chromosomes from the tip of a fast-growing onion root and observe the stained chromosomes at various stages of mitosis at 400x magnification.<br><br>Use online animations of cells division. Clarify the stages using diagrams to show how the chromosomes pair up, replicate and separate from their partners. Make labelled diagrams<br><br>Compare this to the process of asexual reproduction in unicellular organisms, yeast or bacteria using photomicrographs, etc<br><br>Explain how mitosis maintains the chromosome numbers and the characteristics of the cell or tissue enabling growth and repair in multicellular animals, and rapid reproduction in unicellular organisms to take advantage of improvements in conditions. | Make labelled diagrams or flow charts and summarise the process in bullet points. | Students can identify the function of nuclei in growth by replication of cells.<br>They know that most cells have the same number of chromosomes but this number varies between species<br>They understand that in mitosis the same number of chromosomes is passed on to the next generation of cells.<br>(Mutations and errors are dealt with in the next module but could be incorporated here if preferred) | To see animated cell division and labelled organelles.<br>http://www.cellsalive.com/cam0.htm<br>http://www.cellsalive.com/cells/3dcell.htm<br>Images of chromosomes*:- Google images* e.g.<br>chromosomes.gif,<br>library.thinkquest.org<br>learn.genetics.utah.edu<br>employees.csbsju.edu<br>www.genome.gov<br>Chromosome numbers in different species.<br>http://www.vivo.colostate.edu/hbooks/genetics/medgen/chromo/species.html<br>Hodder Gold C Inheritance and selection p2 nucleus and chromosomes.<br>Collins Revision Guide Chp. 9 p.104 paired chromosomes.<br>McKean Biology Chp. 9 Cloning and asexual reproduction.<br><br>Squash preparation of onion root and other cells<br>www.longman.co.uk/gcsebiology/pdfs/worksheet_9_cells.pdf<br><br>information about different types of microbe i.e. bacteria, archaea, viruses, fungi and protists, and their uses<br>http://www.microbeworld.org/<br>http://www.microbeworld.org/resources/ |

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| continued | <u>Reproduction and meiosis</u><br><br>From ESO3 the students should know that male <u>gametes</u> (sperm) combine with the female gamete (egg cell) There are animations to demonstrate this if revision is necessary. Ask what would happen if the 46 chromosomes in a male cell combined with the 46 in the female over a number of generations and ask them to suggest how this result could be avoided.<br>Describe the reductive process of meiosis, using diagrams, online animations, video etc of how cells divide to form male or female gametes. Have pairs of students prepare a small number of paper strips as chromosomes, A, a, B, b, etc., coloured or labelled, and physically pair them up and separate. Follow the process through to form the gametes. Combine the gametes of one pair with the gametes of another student to see the whole number re-emerge. | Prepare a flow chart for the process. | Students understand the process of meiosis results in a reduction in chromosome number by half. | Animations for meiosis<br>http://www.abpischools.org.uk/resources/genome/dna4.asp<br><br>http://www.cellsalive.com/meiosis.htm<br>Meiosis, animated with sound effects.<br><br>Collins Science plus 2 page 26-33<br>My Genes<br>McKean Biology Chp. 22 and 23, Heredity,<br>Collins Revision Guide Chp. 9 p. 103-4 mitosis and meiosis.<br><br>Missing word activities for mitosis and meiosis and table showing the genetic codes for some amino acids.<br>http://www.biotopics.co.uk/genes/trans.html |
| 1-2 Core | <u>What is DNA?</u><br><br>Arrange for the students to extract DNA from suitable fruit such as strawberries or kiwi fruit. The macerated fruit is mixed with simple kitchen products e.g. detergent, and the DNA is separated using pure alcohol. Can be carried out at home. | Students carry out the extraction of DNA and write a report on their procedure. | Students experience practical use of materials, understanding the need for care and close observation. | How to obtain DNA samples from strawberries<br>http://www.thetech.org/genetics/medicine.php |

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| continued | Teach about the helical structure of DNA. Using textbooks, slides from the internet, commercial models show how the nucleotides are composed of base pairs, A-T and G-C attached to strands of ribose sugar and phosphate. Then let the students create models of DNA, using commercial kits or, more creatively, with sweets or simple components. See resources for sites for instructions for home-made models.<br><br>DNA replication can be enacted by role-play, students taking positions in pairs of bases labelled C-G or A-T with others as frame of phosphates and ribose molecules. New partners enter when an enzyme separates the strands of the helix. A further enzyme/person could link the new pairs with the complementary bases. Or use the models made earlier.<br><br>Demonstrate the complex shape of the whole DNA molecule as it forms chromosomes by twisting a rope or cord until it loops back on itself, noting that this doesn't give the full picture.<br>Ask the students to imagine how they would interpret the fact that organisms grow to look like their parents, or repair themselves with similar tissue, if they didn't know that DNA existed. How would a modern scientist respond to an old wives' tale about a hare-lip or cleft palate being caused by the mother seeing a hare when pregnant? What kinds of questions or problems can scientists investigate if they know there is a self-replicating molecule at the heart of all living organisms? How could knowing about DNA affect our food production or the battle against disease?<br>Tell them that these matters will be studied in detail in the next module. | The students make models that show understanding of the pairs of bases or nucleotides, and describe, or answer questions about, the process of replication using letters to refer to complementary bases.<br><br>Students look at examples of models of DNA and compare to assess how easy they are to understand. | Students know chromosomes are made up of long, coiled molecules of DNA, containing chemicals called bases and that there are four different bases divided up into regions on chromosomes called genes<br>Student know that each gene contains a different sequence of bases | Explore the DNA molecule<br>http://www.pbs.org/wnet/dna/<br><br>Models of DNA:-<br>Other people's ideas<br>http://www.ncbe.reading.ac.uk/DNA50/models.html<br>ones students can make:<br>Balls and sticks, well-illustrated<br>www.miniscience.com/projects/DNAmodel/index.html<br>Using sweets, well-illustrated<br>http://library.thinkquest.org/19037/making_a_candy_model.html<br>Replication - interactive<br>www.biotopics.co.uk/genes/<br><br>Collins Revision Guide Chp. 9 p102 DNA<br>p.106 genes and proteins.<br><br>A table showing the genetic codes for some amino acids.<br>http://www.biotopics.co.uk/genes/trans.html<br><br>McKean Biology Chp. 21<br>Chromosomes and genes. |

**Topic: Heredity and Transmission**

**Assumed knowledge**

The cell as a basis of life; its typical components, forms and functions and the correct terminology for cytological structures.
Relationship of variation in cell type to structure and function of living things.
Basic processes of reproduction in and life cycles of plants and animals.
Cell division, chromosomes, mitosis and meiosis. The structure and importance of DNA.

**Content of this module**

1 Mendelian inheritance; solving simple problems using Mendel's laws.
2 Human genetics, sex determination and sex-linked hereditary diseases.
3 Genes and the genetic code; mutations in the chromosomes.
4 Genetic engineering and manipulation; the most important applications, repercussions and harmful consequences. Genetically modified food; Cloning; The human genome project.
5. Ecological, social and ethical implications of advances in genetic and reproductive biotechnology.

Time for this module, 12 lessons, approximately 12 hours and up to 3 extension lessons 3-4 hours

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
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| 1-2 (Longer if covering variation more deeply) Core | Who do you most resemble? (If possible ask students in advance to bring in photos of family members.) Ask the students to tell a partner what physical traits they have and whom they most resemble. Discuss whether children always resemble one parent or are they a blend? (continuous and discontinuous variation is referred to later but could be covered at this point) What do we mean by terms like characteristics, features, character, inheritance, and variation? Brief outline of Gregor Mendel's studies of the inheritance of characteristics in pea plants. Remind students that meiosis halves the number of chromosomes in the gametes and that each gene is matched by a partner (allele) Demonstrate with students each holding two cards labelled T that two tall individuals crossbreeding produce only tall offspring. The offspring receive two T cards, one from each parent. Repeat with two students representing small plants, with two cards labelled t. Ask the class to discuss and predict in small groups what will happen if a TT crossbreeds with a tt before explaining to the group. Record by mapping diagrams what happens in each of these crosses. Relate the results of crossing of TT and tt to Mendel's work; all the first generation was tall plants. Elicit or explain that "tallness" dominates over "shortness". Introduce the terms heterozygous and homozygous and draw diagrams to show that different alleles were present on the chromosomes before meiosis in the TtxTt case | **LL** Look at Hutchinson encyclopaedia entry for a brief biography of Gregor Mendel Answer questions about his life and work.<br><br>Look at other internet sites, research and write own biography of Mendel.<br><br>Groups or individuals explain different forms of crossbreeding to the class using materials they have made.<br><br>Comprehension exercises and glossary work .**(LL)** | The students understand the basic concepts of inherited characteristics.<br><br>The students can retell the main points of Mendel's life.<br><br>The students can represent/act out the crossbreeding process and explain in simple terms what is happening. They can give the percentage of offspring with a specific genotype.<br><br>The students can define the key terms underlined opposite. | Collins Science plus 2 Chp 26 My genes.<br>Absolute Science 3 Chp 6 p 77 has a photograph of an extended family sharing distinctive features.<br><br>Mendel<br>http://www.bbc.co.uk/schools/gcsebitesize/biology/variationandinheritance/3evolutionrev3.shtml<br>Mendel museum and activities<br>http://www.fieldmuseum.org/mendel/<br>Biography<br>http://www.fieldmuseum.org/mendel/story_life.asp<br><br>Biography of Mendel in Spanish with portraits: BBCmundo.com.<br>http://news.bbc.co.uk/hi/spanish/science/newsid_1594000/1594562.stm<br>rapid life cycle seeds for studying Mendel's laws<br>http://www.philipharris.co.uk/teaching.htm<br><br>Collins Revision Guide Chp p.107 dominant/recessive.<br><br>Cards to represent genotypes.<br><br>Quiz on Mendelian genetics<br>http://biology.about.com/od/mendelianggenetics/Mendelian_Genetics.htm |

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| 1 Core(Could be 2 hours combined with first lesson) | Resume the work on Mendel's work with a revision of the simple crosses of TT and TT, tt and tt and TT and tt, with diagrams.<br>Explain that since this was pioneering work, Mendel could not be certain what the reason for the results was, so he bred a further generation, by self-fertilising the flowers of the hybrid cross Tt. It may be necessary to remind students about the parts of plants that are involved in reproduction. A labelled diagram could be helpful. Ask pairs to work out together what might happen if Tt breeds with Tt.<br>Work through the conclusions as a class, introducing a Punnett square to help setting out the gametes, T, t, T, t and the three genotypes. (see below). Work through other examples of Mendelian inheritance; e.g. tongue rolling, free earlobes, cystic fibrosis, possibly as homework.<br>The two laws of Mendelian inheritance should be given and discussed in the light of this work.<br>First law: Segregation of characteristics; i.e. for each pair of characteristics, only one gene will be on a gamete.<br>Second law: Independent assortment; i.e. for two characteristics the genes are inherited independently. | Drawing mapping diagrams to explain crossing for monohybrid inheritance.<br><br>Using a Punnett square to find all the genotypes. | The students can explain simple crosses, draw diagrams to explain monohybrid inheritance, use a Punnett square to calculate the ratio of each phenotype and discover all the possible genotypes.<br>The student is familiar with and can use the terms underlined in discussing their work. | Mapping diagrams from previous lesson of crossbreeding.<br><br>Labelled diagram of flowering plant.<br><br>Large Punnett square to demonstrate.<br><br>Collins Science plus p.30 Punnett square.<br><br>Collins Revision Guide Chp 9 p.107 monohybrid<br>p.108-110 Punnett square.<br><br>Online practice drawing crosses and working out ratios<br>http://www.bbc.co.uk/schools/gcsebitesize/biology/variationandinheritance/0dnaandgenesrev7.shtml<br><br>Mendel's laws<br>http://www.purchon.com/biology/mendel.htm<br>Recessive genes<br>http://www.answers.com/recessive%20genes |

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| 1 Core | Sex determination<br>Provide photos or projection slides showing human chromosomes in their condensed form. Discuss the shapes, approximately H or X and explain that humans have 23 pairs of chromosomes. Challenge to students to pick out potential pairs. Without specialist training this is extremely difficult and only a few minutes should be spent before conceding defeat. However, point out that there is one distinctively different chromosome in one of the slides/photos. It has no match. Tell the students that this nuclear material is from a male human and ask them to suggest why this one is different. Show prepared slides or photographs showing chromosomes from female and male cells in pairs and locate the unequal pair. Ensure the students understand that humans with XX will be female and XY will be male.<br>Refer back to meiosis and the formation of gametes and use a Punnett square to look at the outcomes for crossing XX and XY.<br>Sex-linked Inheritance<br>See if the students know any sex-linked characteristics, possibly from their families, e.g. colour blindness. Genes carried on the X or Y-chromosomes are sex-linked. Explain that many are carried by the female since the Y chromosome has very few genes and having a normal gene on the other X chromosome hides the condition. Explain colour blindness with a Punnett diagram for a carrier female (XNXn) and a normal male (XNY) where (n) is the recessive gene and N is the dominant gene.<br>Students can work through other examples of sex-linked conditions, e.g. haemophilia, cystic fibrosis, etc. possibly as homework. | Respond in a quiz at the end of the lesson to questions about human chromosomes sex determination, and sex-linked conditions.<br><br>Use a Punnett square to determine sex and the ratios of possible phenotypes with sex-linked conditions.<br><br>**LL** Read accounts of the effect of sex-linked conditions on daily life.<br><br>Match definitions with words underlined or write short explanations of inheritance of a sex-linked condition. | The students know the number of chromosomes in a normal human, and can explain the physical difference between male and female chromosome pairs.<br><br>They can draw a Punnett square for inheritance of sex and some sex-linked conditions.<br><br>They can research another condition and write a short account of how it is transmitted and its affect on the individual<br><br>Students can use the words introduced in the lesson with understanding in their own writing. | PowerPoint presentation of chromosomes from male and females in random array and in paired array.<br><br>Links to inherited illnesses/conditions www.gig.org.uk -downloadable booklets about genetic testing and news reports.<br><br>Cystic fibrosis<br>Personal accounts of living with cystic fibrosis<br>http://www.docsquid.com/mylifecf.htm<br>http://www.abpischools.org.uk/resources/genome/dna6.asp<br>Collins Science plus 2 p.31 cystic fibrosis.<br><br>Haemophilia<br>Transmitted by Queen Victoria:<br>Collins IGSE Biology page 116<br>Collins Revision Guide Chp 9 p. 104 chromosomes pairing<br>p.110 sex-linked inheritance.<br><br>Genes and you is a site with some activities about four conditions, cystic fibrosis, Down's, Huntington's, haemophilia for ESO4 level<br>http://www.gig.org.uk/genesandyoufourgenetic.htm |

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| 1 Core | The genetic code. What is a gene?<br>Revisit the studies of DNA, and its structure, consisting of bases (C-G) and (A-T), and compare these simple components with the Morse code or binary code. In the Morse code the dots and dashes are broken into letters and words and binary code is broken into bits and bytes. Using an enlarged micrograph of *Drosophila m* chromosomes and point out that some of the surface structure can be seen but the genes are even more difficult to locate.<br>This could be illustrated with some sequences of letters in a long word to show how starting in different places would give very different words (e.g. hippopotamus/newspaper).<br>Explain by analogy with words that some combinations appear in many words, e.g. "th" "ou" and many words are compounds of shorter words, e.g. blackbird, blackboard, outcome, outside, etc) and that this happens in nature with genes. The students may be amazed to find out that, genetically, they share characteristics and genes with garden plants!<br>Explain how cellular material can be broken down using enzymes/chemicals that isolate the DNA. This is treated with enzymes that attack specific sites on the DNA strand cutting it into shorter and shorter lengths. These can be separated by highly specific methods, often automated by machine and managed by computer programs, using a gel. | **LL** Read news items and encyclopaedia references to the Human Genome project.<br>Role play interviews with key figures in the research,<br>find out about groups opposing the concept and arrange a simple debate between the protagonists. | The students can explain that genetic, inheritable information is contained in the chromosomes in the form of discrete areas called genes.<br>The students show an interest and understanding of some or most of the issues raised by mapping the human genome.<br>They are able to explain in simple terms the processes and intentions of the research.<br>The students can express their own point of view and use their knowledge to support their case.<br>At a higher level the students are able to express a different point of view to their own or provide a balanced account. | Images of chromosomes*:- Google images* e.g.<br>chromosomes.gif,<br>library.thinkquest.org<br>learn.genetics.utah.edu<br>employees.csbsju.edu<br>www.genome.gov<br><br>simplified explanation of genes humans have in common with other organisms<br>http://www.thetech.org/genetics/common.php<br>Chimp and human genomes<br>http://www.thetech.org/genetics/ask.php?id=69<br>Numbers of genes per species<br>http://www.vivo.colostate.edu/hbooks/genetics/medgen/chromo/species.html<br><br>Image of genes after separation by electrophoresis<br>http://www.virtualsciencefair.org/2004/mcgo4s0/public_html/t5/dna_identification.html<br><br>Collins Revision Guide Ch9.p.102 DNA, p. 113 genetic engineering.<br><br>Sites aimed at teachers of this level<br>www.at-bristol.org.uk/stirring/schools.htm<br>http://www.biology-resources.com/ |

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| Extension<br>Homework or **LL** | Use information technology or the internet to find out about The Human Genome project, which was designed to plot the sequence of DNA bases, and find the locations of human genes.<br>Compare to how, in Morse code, having the dots and dashes, we can find where the words begin and end and then work out what the message is and what the words mean. | **LL** Read news items and encyclopaedia references to the Human Genome project.<br>Role-play interviews with key figures in the research.<br><br>Students work in groups to produce a poster or leaflet explaining the project to non-scientists.<br><br>Find out about groups opposing the concept and arrange a simple debate between the protagonists. | The students can explain in their own words the intention and achievement of the Human genome project.<br><br>The students may be able to list pro's and con's to the research.<br><br>The students may be able to present opposing views about the value of the research in a debate. | Human genome project news report http://news.bbc.co.uk/1/hi/sci/tech/713280.stm<br><br>Poster of timeline for development of understanding of heredity and genetics to download http://www.abpischools.org.uk/resources/poster-series/biotech/timeline.asp<br><br>Collins Revision Guide Chp 9. p.106.<br><br>Table of genes for common amino acids http://www.biotopics.co.uk/genes/trans.html |

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| 1-2 core | Variation and Mutations (1)<br>Where do differences come from? Refer back to the differences and similarities between students and their families considered when looking at Mendel's work. List in pairs what characteristics can vary between unrelated individuals. Then decide which are due to lifestyle or environment and which were inherited, e.g. tattoos, long hair, black skin, athletic physique, obesity, gender/sex, colour blindness. Which characteristics can have any value like height or weight, and have continuous variation and which can only have one of a limited range of alternatives and are discontinuous? This could be continued as a literacy activity debate on the nature versus nurture effects on sporting ability or academic success.<br>Discounting known genetically inherited conditions such as sex, skin colour and colour blindness, Rhesus factor, for example, challenge the students to raise theories about why sisters or brothers are not identical. Encourage debate about the validity of the ideas and how they could be tested scientifically before elaborating reasons. One reason is random assortment of chromosomes passed from each parent to each child. This can be demonstrated with small objects in a variety of colours being shared equally between two small containers. Each time re-mixing and sharing results in a different composition in each container, as in meiosis. One of each pair is represented but the permutations are enormous. The students could be challenged to use mathematics at home to work out the possible combinations for a small number of chromosomes, possibly 4 or 10 pairs. | **LL** discussion of how much our environment or lifestyle influences our person or potential and how much is the result of our inherited characteristics.<br>Students can draw on their studies in science to justify their viewpoint and their literacy skills in speaking persuasively for one point of view or another.<br><br>**HL** The students could look at how poor understanding of inheritance and genetics led to politically questionable assumptions about the rights or potential worth of different groups.<br><br>**NL** students can collect data from the class of features with continuous variation or discontinuous variation, sort into tables and draw graphs. | The student can identify variations between individuals that are probably the result of environmental factors or lifestyle choices and those that are probably due to inheritable factors.<br><br>The student can raise questions or theories about processes and suggest some way of testing the ideas. | A case of variation caused by omission of part of the genetic code at http://www.virtualsciencefair.org/2004/mcgo4s0/public_html/t5/dna_identification.html<br><br>Collins Revision Guide Chp 9 p.101 types and causes of variation.<br><br>Collins Science Plus My Genes p 32, data for variation in height NL. |

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| continuation | Random fertilisation<br>In sexual reproduction there are millions of possibilities for fertilising one gamete with another. This could be represented with short chains of interconnecting beads representing "genes" about four units long coloured in four out of 8 colours. When only one can combine with the female gamete the students can be invited to comment on the effect on the offspring as to what combination of genes are passed on or "lost".<br>Crossing over<br>Remind the students about the process of meiosis and the pairing of chromosomes before separating. A PowerPoint presentation can re-show this step by step. Then show what would happen if the chromatids cross over and then pull apart exchanging short lengths of DNA. This can be done diagrammatically or using the interlinking cubes used earlier. A good analogy is the twisting together of springs from ballpoint pens which, if they could separate like chromosomes, could exchange material.<br>Conclusion:<br>With 23 chromosome pairs and approximately 100 000 genes, discuss how many possible different ways can the chromosomes be different in the subsequent generation? Observe the level of understanding of the huge diversity possible from the suggestions and estimates the students give. | Challenge the students to work in small groups to prepare a poster explaining one of the possible causes of variation both continuous and discontinuous covered in the lessons so far. Try to ensure that all aspects are covered and display the posters in the class for discussion and analysis by the other groups and then on a long corridor wall with notices inviting and challenging other students to interpret them. | Students can explain the mechanism of at least one process leading to inheritable variation.<br><br>The students can use the words underlined in short pieces of writing describing the processes.<br><br>The students demonstrate a wide range of understanding in answering questions or debating issues. | Beads in 8 colours and string/thread or interlocking plastic blocks e.g. mathematical cubes. Not Lego!<br><br>Slides or video clip showing the process of meiosis.<br><br>Example of errors in replication and cell division<br>see references to Downs syndrome.<br><br>Teenager Melissa explains the affect of Down syndrome on her life. (LL)<br>http://www.nationalgeographic.com/ngkids/0612/2.html<br><br>Collins Revision Guide Chp 9 p. 101 variation, p. 104 meiosis.<br><br>Table of genes for common amino acids<br>http://www.biotopics.co.uk/genes/trans.html |

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| 1 Core | Variation and mutation (2)<br>(The variation caused by mutations could be continued as part of the previous lesson or separately.)<br>In the previous lesson ask the students to bring in images of superheroes and monsters, such as Spiderman, the Incredibles, Teenage Mutant Ninja Turtles. Ask the students to describe their favourites special powers and features. Briefly collect lists of how these powers or changes were attained. Discuss as scientists the likelihood that these powers could be inherited by the offspring of the heroes. Conclude that they can only be inherited if they affected the genes.<br><br>Present images of variations between 'normal' forms and different forms, e.g. leopard and black 'panther', the three forms of peppered moth *Biston betularia*, and explain that the normal form suffered a mutation which created an inheritable change to the genes of these animals. The effect of a mutation is to change what happens in each cell, usually for the worse. However, for these animals the change has been neutral, or helpful. The affect of a mutation could be demonstrated by composing a sentence which makes sense and then altering one word or even one letter to change the sense (e.g. The duck walked away >in steps to> the dock talked all day) or use a game of whispers. Most mutations are spontaneous but some are caused by environmental agents.<br><br>A presentation explaining the effect of predation and natural selection of the peppered moth could be used here. Analogies can be drawn with evolutionary pressures in the past, e.g. Darwin's finches in the Galapagos islands. | **LL** Students could find out about theories proposed in the past about variation, such as Lamarckism or Darwinism and compare to the effect of mutations.<br><br>Students can research into other changes due to mutations.<br><br>A Punnett square can be used to show how the black panther inherits its recessive gene from its parents.<br><br>Students could prepare a presentation about extinction or evolution of particular species relating to selective pressures as opposed to catastrophic events. | The students can relate variation in natural populations to mutations in the genetic code.<br><br>They can explain how selection can occur through environmental factors acting on particular phenotypes.<br><br>They know that some variation through mutation is spontaneous and some is caused by environmental factors. | Posters and photos from magazine of hero characters.<br><br>Collins Revision Guide Chp 9 p. 101.<br><br>Detailed information about the peppered moth is available on wikipedia with maps of its distribution and there are many sources of photos of the various forms.<br>http://en.wikipedia.org/wiki/Peppered_moth_evolution<br>map of distribution<br>http://www.talkorigins.org/faqs/wells/images/grantfile.jpg<br>Image and Spanish text.<br>www.ucm.es/.../biston%20betularia%2005.jpg<br><br>Table of genes for common amino acids<br>http://www.biotopics.co.uk/genes/trans.html<br><br>(For a simulation of predation and natural selection, see the Dynamics of Ecosystems module, modelling birds feeding on snails). |

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| 1 Extension | The significance of mutations can be demonstrated by referring to the common cold or influenza, which constantly mutate and therefore humans have to produce fresh antibodies tailored to each new variant.<br>Similarly rats can become immune to poisons and headlice to insecticidal shampoo. The importance to health can be demonstrated by reference to mutant strains of bacteria that resist treatment by antibiotics, such as methicillin-resistant *Staphylococcus aureus* (MRSA) or *Clostridia dificile*.<br>Using discs such as Othello game pieces, demonstrate that the bacteria divide replicating their DNA for a long time but occasionally one will produce a mutation (Turn over one piece) This spontaneously creates a different protein in the cell wall of all subsequent individuals. (Replace the different piece with two then 4 of the same colour) When an antibiotic is used against the bacterial infection that only attacks the first form, only the mutant strain remains. (Remove all the pieces of the first colour). The host recovers, partly because the infection is reduced sufficiently for the body's own defences to work. However, while infected the host is infectious. The resistant strain is spread through the host population. It infects individual hosts without their own immunity and is not treatable with that antibiotic. When a new antibiotic is eventually found, resistance can arise to this in the same way. Sometimes a mixture of antibiotics is used to treat infections to reduce the possibility of survival by mutated bacteria. | Continued below<br><br>The students can find out what treatments are offered by the medical services for illnesses caused by viruses, e.g. flu, rabies, HIV and how this differs from those caused by bacteria, e.g. food poisoning, eye infections, or fungi, e.g. thrush, athletes foot.<br><br>They can create tables to compare treatments using anti-microbial methods and those using diet or hygiene practices to overcome infections. | Continued below | Resistant bacteria mutations<br>http://www.bbc.co.uk/schools/gcsebitesize/biology/variationandinheritance/3evolutionrev3.shtml<br><br>Photo of MRSA<br>http://www.answers.com/main/Record2?a=NR&url=http%3A%2F%2Fcommons.wikimedia.org%2Fwiki%2FImage%3AMRSA7820.jpg<br><br>News of outbreaks of antibiotic resistant strains is available in current affairs/news sites. At the time of writing,<br>e.g. MRSA<br>outbreakhttp://news.independent.co.uk/uk/health_medical/article2083867.ece<br>or *C. dificile*<br>http://archive.malverngazette.co.uk/2005/8/27/372699.html<br><br>Report containing statistics suitable for making charts, discussing percentages, and using IT for datahandling<br>http://news.scotsman.com/scotland.cfm?id=11192007 |

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| Extension continued | Methicillin-resistant *Staphylococcus aureus* (MRSA) is a specific strain of the *Staphylococcus aureus* bacterium that has developed antibiotic resistance to all penicillins, including methicillin and other forms of penicillin antibiotics. MRSA was first discovered in the UK in 1961 and is now widespread, particularly in the hospital setting where it is commonly termed a superbug. *C. Dificile* is rapidly overtaking it in deaths, especially amongst the elderly. The students can look at statistics on levels of infection represent them in various forms using datahandling programs and incorporate them into their own reports.<br>Ask the students to suggest other methods of combating bacteria which would not lead to resistance being acquired. | Can they suggest consequences to farmers feeding antibiotics to their livestock on the health of humans?<br><br>**LL** Can they write a letter objecting to the practice setting out the scientific arguments? | The students show understanding of the cause of resistance to antibiotic treatment and the consequences of misuse of antibiotics.<br><br>The students suggest alternatives that avoid resistance building up. | |

A Punnett square sets out the possible combinations that genotypes can make from the gametes in the parent cells
It helps calculation of the ratios of one phenotype to another. It was invented about 1920 by RC Punnett.

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| 1 Extension | Inheritance of co-dominant genes<br>Blood groups The students may know their blood group and whether or not it is the same as one or both of their parents. A brief explanation of the reaction between antigens on blood cells from a donor with antibodies present in the blood of a person with a different blood group receiving a transfusion that could be fatal. The antigens can be identified giving the blood group of each individual. The genes for the antigens are not dominant or recessive, A and B are co-dominant, but both dominate O. Punnett squares can be drawn to represent crosses between all possibilities, AA, BB, OO, AB, AO and BO.<br><br>For comparison, the simpler inheritance pattern of the Rhesus factor in blood can be drawn out. The possible medical consequences of incompatibility between the maternal and foetal blood can be explained.<br><br>Sickle cell anaemia:<br>This is thought to have arisen as a mutation. Those with normal haemoglobin H are easily infected with malaria. Those with abnormal haemoglobin h suffer severe symptoms when stressed by lack of oxygen and often die young, but those with both co-dominant genes are protected against malaria, and have reduced symptoms. The gene, although dangerous, persists in the population because of its protective effect. | The students can try to explain their diagrams to each other and answer questions on possible outcomes of crosses.<br><br>Students could be asked to debate the consequences for the gene pool if malaria were to be eradicated, or if global warming extended the range of the carrier mosquito into Northern climates. | The students understand the importance of blood grouping in protecting lives of those undergoing blood transfusion in operations.<br><br>The students can follow the steps in drawing a Punnett diagram demonstrating the different genotypes and phenotypes.<br><br>They may be able to draw parallels between the mutation for sickle cell anaemia and the dark/light forms of the peppered moth. | Inheritance of blood groups<br>Long verbal explanation of blood groups and importance in transfusions<br>http://www.purchon.com/biology/abo.htm<br><br>Sickle cell anaemia<br>long detailed account no Punnett diagrams, info from wikipedia<br>http://www.nowtryus.com/article:Sickle-cell_anemia |

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| 1 Core | <u>Genetic engineering and manipulation</u><br>(Recombinant DNA technology)<br>In a previous lesson ask them to look for references in the news or on the internet to these themes and bring to the class.<br>Review what the students know about genetic engineering, for example when did it start? (1970s). How is it carried out? This can be presented as a flow chart or PowerPoint presentation.<br>(Using enzymes to cut useful genes from DNA. Insertion of the genes using enzymes into a carrier or vector, usually a virus that naturally infects bacteria or yeast. The host cells, bacteria or yeast, are infected with the virus which transfers its DNA and the useful genes into the host. The host produces the desired protein or other product in giant fermenting tanks. The product is harvested, refined of host cells and virus and prepared for use).<br>What products are made this way? (human insulin, human growth hormone (the first application of the new technology) normal mucus for cystic fibrosis treatment, protective toxin for tomatoes and tobacco plants against insect attack).<br>More examples come to light all the time. (See the ABPI site). | **LL** Use materials such as the Observer 2002 review of genetic science to discuss issues. E.g. "Steve Jones - professor of genetics at the Galton Laboratory, University College, London, and a top popular science writer himself - [said] that [designer babies} is a fake issue arising from the 'huge overselling of genetics that has been going on almost since the science began. The problem is that people who are not scientists - and some who are - are using science to explore questions which are not scientific but have to do with ethics or identity or social change.' Debate who should explore the questions, scientists or non-scientists? Are questions of ethics outside science? | The students can list some of the issues they have found in the press or internet or those they have learnt about in class and identify different points of view. They begin to identify language used to persuade and identify bias in reporting scientific issues.<br><br>Some may be able to present their views on the issues using their knowledge of genetics so far; others may be able to list opposing views as an argument. | A case of variation caused by omission of part of the genetic code at http://www.virtualsciencefair.org/2004/mcgo4s0/public_html/t5/dna_identification.html<br><br>Timeline for development of understanding of heredity and genetics http://www.abpischools.org.uk/resources/poster-series/biotech/timeline.asp<br><br>Text version review of the trends in recombinant DNA and other technologies 22 December 2002 http://observer.guardian.co.uk/print/0,,4572311-110190,00.html<br><br>Collins science Plus 2 Chp 26 My genes p31, ethics of change, genes as therapy, designer babies, abortion of foetuses for genetic defects.<br><br>Collins Revision Guide GCSE Chp. 9 p 113. |

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| 1-2 Core | <u>Applications of genetic engineering and biotechnology</u>.<br>Look at examples from current or recent news for those applications the students will be most familiar with.<br>For example:- Genetic fingerprinting is used in forensic science to identify criminals, e.g. arsonists or rapists, or settle paternity cases. Remind the students that the huge variety of DNA possible between individuals makes identifying actual paternity difficult but it is possible to eliminate those men whose offspring it could not possibly be. As in other techniques, the DNA is extracted and broken up by enzymes into fragments, which can be separated by electrophoresis. This can be compared to maternal and presumed paternal DNA. (See the example in "Resources").<br><br>The effect can be demonstrated by separating colours from ink or dye by chromatography using water and filter papers.<br><br>Other examples students may be aware of :-<br><br><u>Genetically modified plants/food.</u><br>Refer to the variety of ways that genetic modification has entered the food chain already<br><br>E.g. Antibiotics are produced in fermenters using fungi modified to mass-produce new, more specific antibiotics.<br><br>(continued below) | Students use chromatography to separate materials and compare the method to descriptions of forensic techniques.<br><br>Students may be able to point to recent cases in the mass media where the techniques have been employed to solve a crime. | The students know that the genetic information contained in the chromosomes and DNA can be used for a variety of purposes.<br><br>They can suggest a range of implications for health of individuals and populations. | A photo comparing DNA of three related individuals showing omission of part of the genetic code at http://www.virtualsciencefair.org/2004/mcgo4s0/public_html/t5/dna_identification.html<br><br>Collins Revision Guide Chp 9 p.105 genetic finger printing.<br><br>Text version review of the trends in recombinant DNA and other technologies 22 December 2002 http://observer.guardian.co.uk/print/0,,4572311-110190,00.html<br><br>References to selective breeding for comparison with genetic modification. e.g.<br>Collins Revision Guide Chp 9 selective breeding p. 111.<br><br>Collins Absolute Science 3 selective breeding p. 83. |

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| Continued | E.g. genetically modified yeast to produce "lite beer" or stronger alcoholic drinks, disease-resistant food plants such as tomatoes, weedkiller resistant cereals to make maintaining clean fields easier, the removal of toxic elements from oilseed rape to make the oil extracted edible to humans.<br>If the students are unaware of wider applications, draw their attention to other examples such as:-<br>New varieties of bio-fuel crops are being developed by genetic modification of crops such as corn, to increase drought resistance and yield and to reduce the cost or increase the efficiency of ethanol production. Modification of enzymes that will convert crop waste of plants which consist largely of hard-to-break-down cellulose efficiently into ethanol.<br>How do students respond to news that Argentina has recently established incentives to expand GM soya bean cultivation for bio-diesel use?<br>GM tree plantations could cross-pollinate with non-GM trees and contaminate the remaining natural forest over hundreds of miles.<br>Compare GM to the selective breeding of previous centuries, which has produced the huge variety of roses, dogs and ornamental fish from the original living things.<br>Elicit a list of differences between the two approaches and possible advantages and problems arising from genetic manipulation as a means of producing new strains.<br>Display statements about the perceived risks of novel genetic materials entering the wild population of related plants from campaigning organisations and discuss and compare. | Students prepare tables comparing selective breeding with genetic modification or write a short comparison.<br><br>**LL** The large quantity of material available makes this an ideal literacy topic, with implications for Citizenship and History and Geography links e.g. Students compare the positive views of scientists and agriculturists with those of protest groups such as Friends of the Earth, Actionaid, Christian Aid.<br><br>**GL** The students can research or study in Geography the economic effects on developing countries of the new GM crops.<br>Or<br>**CiL HL** Write newspaper articles. Prepare debates. | Students use their knowledge to suggest repercussions; advantages and problems arising from genetically modified plants. | Report on bio-fuels The Ecologist, 29 March 2007<br>http://www.theecologist.org/archive_detail.asp?content_id=831<br>See also Scientists for Global Responsibility site at<br>http://www.sgr.org.uk/GMOs.html<br><br>GM bio-fuels<br>www.gmwatch.org/print-archive2.asp?arcid=7814<br>http://www.primalseeds.org/daviot.htm<br><br>Genetically modified ice cream article<br>http://news.independent.co.uk/environment/article1168240.ece and<br>http://www.indsp.org/Unilever-GM-IceCream.php<br><br>Who's afraid of Frankenfood?<br>www.time.com/time/magazine/article/0,9171,34817,00.html<br><br>The views of the cereal breeders at<br>www.monsanto.co.uk/news/ukshowlib.phtml?uid=1889<br>And the opposition at<br>www.foe.co.uk/resource/press_releases<br>www.guardian.co.uk/gmdebate/Story/0,,201269,00.html<br>www.genewatch.org |

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| 1 Core | Repercussions and most important challenges.<br><br>Polarisation of views about research leads some people to mistrust science, scientists and new technologies in general. The repercussions need to be managed by an informed society. The challenge is to develop the skill to identify benefits and threats and sift the evidence amongst the students.<br><br>Genetic Therapy<br>Discuss what benefits could flow from treating disease at a cellular level. How should we choose how to apply new techniques, who should be treated, what conditions should be treated and which left to "nature"? For example:<br>Most people die of the diseases of ageing, which are genetic. Then there are all the other, rarer conditions which still affect millions, from Parkinson's to diabetes, cystic fibrosis to Down's syndrome, spinal cord injuries and Alzheimer's which stem-cell research may one day help.<br><br>If genetic cures are developed, how would the students decide responsibly who to help and who not to? It is already possible that cystic fibrosis could be treated by modifying genes. Should we treat it by gene therapy? If obesity could be treated genetically, avoiding heart disease or if we could treat eating disorders, should we? What would the students refuse to treat? What would be their priority? | Students can prepare information leaflets about a field of research that interests them.<br><br>**LL** They could role-play a television debate between opposing points of view having assembled the information.<br><br>**NL** They could carry out surveys of opinion and graph the responses.<br><br>**NL** Students could analyse and graph records of the numbers suffering various conditions as percentages of the population.<br><br>**NL LL** They could find statistics on the cost of research in some areas and debate whether this would be better spent on care for sufferers. | The students show a grasp of the complexity of the issues and use their scientific skills of analysis in debates and presentations in literacy and analyse data presented to them, raising questions about them, e.g. about what percentages mean in real terms or financially. | (Continued from GM resources)<br>Strong opposing views to GM<br>http://www.gmwatch.org/archive2.asp?arcid=340<br>Could be used for comparing text and language types in literacy. LL<br><br>In favour of genetic manipulation:-<br>www.gig.org.uk for information about possible gene therapies for inheritable conditions<br><br>"Celebrating 50 years of DNA. [He] argued that DNA offers tremendous promise" read the rest of the article at<br>www.gig.org.uk/docs/gig-news-july-03.pdf |

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| 1 Core | <u>Social and ethical implications of genetic and reproductive biotechnology</u><br>Cloning:<br>Ask the students what the word means to them. Remind them about aspects covered earlier. Normal reproduction of bacteria is to produce identical clones through mitosis. Horticulturists produce roses and trees routinely through cloning, i.e. taking cuttings, and plants like brambles and strawberries do so naturally. It may be appropriate to show a short video clip of chromosomal material being inserted into a mother cell.<br><br>When Mendel produced his peas he could not maintain the first generation cross' unique genetic code. By cloning, plants can be reproduced with exactly the same genes, if necessary in laboratories from tiny clumps of cells on nutrient plates.<br>It is much more difficult to do so from animals above the lowest groups. Very few attempts have been viable. At what point would the students feel cloning should stop? Food animals? Rare species in danger of extinction? Novel varieties of plants with new important characteristics, e.g. producing chemicals for treating cancer? Never be used in animals? Illegal for humans?<br>Should the human genome project be used to decide what is a "normal" human? Should pharmaceutical and biotechnology companies own parts of the human genome as copyright? | Students can compare natural cloning techniques such as cuttings, stolons, rhizomes, and grafts with microculture in laboratory conditions.<br><br>**LL** Students prepare debates or interviews on aspects of cloning.<br><br>**NL** They could carry out surveys of opinion and graph the responses. | The students show a grasp of the complexity of the issues and use their scientific skills of analysis in debates and presentations in literacy. | Collins Science Plus 2 Chp 26 p.31.<br><br>Collins Revision Guide Chp. 9 p.112 Cloning.<br><br>Absolute Science Chp. 6 p.85 cloning Dolly. |

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| 1 Core | <u>Reproductive biotechnology</u><br><br>Briefly revise the monthly release of an ovum, and the problems that lead to reduced fertility. Remind about fertilisation of ovum and sperm and the use of in vitro techniques where there are problems in normal reproduction. Ask the students what might happen if doctors in the future could analyse the embryo and detect genes critical to the survival of the foetus or health in later life, e.g. haemophilia, spina bifida. If we can select which embryos to implant depending on their genetic make up, e.g. screening for breast cancer, Down's syndrome or spina bifida, should we? Or could we add beneficial genes? Should we make it illegal to consider eye colour but not short-sightedness? Point out that earlier civilisations preferred boys, could biotechnology be used to increase the ratio of one sex over another? Would it matter? | | Students use their knowledge of the science of reproduction and the new technologies to explore the social implications of future developments in these fields and devise criteria to guide decisions about the application of the science. | |

**Topic: The Origin and Evolution of Living Organisms**

**Assumed knowledge:**

Inheritance and the environment can cause variation within a species.
Predation, disease and competition for food can cause large numbers of organisms to die.

**Content of this module:**

1 Hypothesis of the origin of life on Earth.
2 The main steps in Darwin's theory of natural selection leading to the evolution or extinction of species.
3 The evolution of living beings using creationism to explain the development of life on earth.
4 Organisms have changed over time and fossils provide evidence for these changes.
5 The evolutionary process in humans.
6 When environments change some animal and plant species evolve and survive but many become extinct.
7 The increase in biodiversity as a result of evolutionary processes.

Time for this module: 6 core lessons , 3 extension activities.

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
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| Core | Pupils view suitable audio-visual material to Initiate debates on evolutionary theory.<br><br>Looking at visual representations of evolutionary development such as the horse and then the human, developing ideas on how these changes occurred.<br>Students to anticipate what the next stage of the evolutionary process will be for man, representing their ideas as artistic impressions. | **HL**<br>Generate questions about evolution to begin to hypothesis the origins of life on earth.<br><br>Evaluate artistic impressions of future man.<br>Observe whether pupils are able to suggest scientific explanations for their ideas. | Students start to show an understanding on one theory of evolution being able to state that all species of living things have evolved from simple life forms which developed billions of years ago.<br><br>Study the evolutionary process in humans. | Collins GCSE revision guide: Biology. Unit 9 Evolution, Pages 115-119.<br>www.guiness.com<br>Choose the advert section and select evolution. This advert visually gives a very good lesson starter.<br>Science Plus Bk. 1. Page 18.<br>The evolution of man<br>Evolution of the horse images;<br>http://upload.wikimedia.org/wikipedia/en/thumb/d/dd/Horseevolution.png/275px-Horseevolution.png<br>Evolution of man images;<br>www.naute.com/pictures/evolution.phtml<br>http://www.scienceagainstevolution.org/v8i1f.htm |
| Extension | The Flores man. Does this change the theories on the evolution of man?<br>Using newspaper articles on the Flores man, write an extra article for an encyclopaedia entry on the evolution of man. | **LL**<br>Assess encyclopaedia entry. | Study the evolutionary process in humans. | Newspaper articles describing the discovery of the Flores Man:<br>www.nature.com/news/specials/flores/index.html<br>www.guardian.co.uk/international/story/0,,1337643,00.html |

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| Core | Explain the term adaptation, and comment on the way animals best adapted to their environment survive and reproduce, while those least well adapted do not. Use the words variation, over-production and competition.<br>Introduce the stages of natural selection using a given example e.g. cactus, include how the cactus with longer roots, more water storage in stem etc were able to survive and pass on favourable alleles to offspring.<br>Students to choose an animal or plant and draw a cartoon strip to show how this organism has been naturally selected and which characteristics have been passed on to offspring. | Evaluate the cartoon strip considering if the students have illustrated all the stages of natural selection. | Pupils are aware of the theory of evolution which states that all species of living things which exist today have evolved from simple life-forms which first developed more than three billion years ago.<br>Pupils should be able to describe the stages of natural selection and how it leads to evolution. | Simulated evolution by natural selection:<br>http://home.pacbell.net/s-max/scott/simevol.html |
| Core Investigation | Carry out a simulation of selection. Use red and green plastic cocktail sticks - a hundred of each colour will be required.<br>Randomly distribute the sticks in a 15 x 15 m square of grass before the lesson.<br>In-groups of 6 learners, ask pupils to act as 'song thrushes' predating the red and green '*Cepaea* snails'. They are allowed to predate for 30 sec's to collect as many snails as possible. Results are scored individually. Repeat a number of times and total the number of 'snails' predated for each of the 'birds'.<br>The selective advantage of the green snails should be evident. Provide some real (second-hand) data to confirm this. | **NL**<br>Practical investigation. Students to collect data, using tables. Observe whether students are able to suggest explanations for observations using scientific knowledge including how natural selection could lead to evolution. | | Resources for simulation of selection:<br>Cocktail sticks x 200<br>Second-hand real data<br>15 m string marker. |

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| Core | Match drawings of Darwin's finches to their food. Discuss Darwin's idea that all living things evolved from simple life forms.<br><br>Collect information on how Darwin's theories were received and discuss two main points that offended religious authorities of the time. Man descends from monkeys' and denying Gods role in creation.<br><br>Read, discuss and analyse Genesis 1-3,<br>Ask the pupils to answer these questions: What do you think Genesis 1-3 is about? Do you think that the universe was created in six days? Ask pupils to explain their views. | Assess understanding in answers to Questions 4 and 6, page 71 AQA GCSE Science.<br><br>**LL**<br>Oral presentations, focussing on pronunciation and vocabulary used. | **HL, CiL**<br>Explain why Darwin's theory of evolution was only gradually accepted<br>Compare different theories of evolution and explain why some are better than others.<br><br>Explain the nature and meanings of the Genesis creation stories for theists, creationists and others.<br>Explain their own responses to the Genesis creation stories. | Darwin's finches (pictures); www.truthinscience.org.uk/site/content/view/53/65/<br><br>AQA GCSE Science Page 71: Analysing theories of evolution.<br><br>Video clips giving information on a variety of evolution topics. Good to use as lesson starter. Answers questions such as;<br>Who was Charles Darwin?<br>How do we know evolution occurs?<br>How does evolution really work?<br>Why is evolution controversial?<br>http://www.pbs.org/wgbh/evolution/educators/teachstuds/svideos.html<br><br>The bible.<br><br>www.nap.edu/readingroom/books/evolution98/evol6-b.html |

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| Core | Demo: The Chemical fossilisation of a sponge.<br>(ideally this demo would have been set up at a week in advance so the outcome can be seen)<br>Show students the sponge before and after the process.<br>Q/A session: What happened to the sponge?<br>Compare what happened to the sponge to what happens to bones buried in sediment.<br><br>Pupils look at a selection of different fossils and discuss how each one was formed.<br>.<br>Students could be asked to study photographs of fossils (for example Archaeopteryx) and consider which animals they most closely relate to.<br><br>Students could make their own impression fossils. | | What Evidence Exists for Evolution?<br>Fossils are the "remains" of plants or animals from many years ago, which are found in rocks. Fossils may be formed in various ways including:<br>from the hard parts of animals which do not decay easily;<br>from parts of animals or plants which have not decayed because one or more of the conditions needed for decay are absent;<br>when parts of the plant or animal are replaced by other materials as they decay;<br>as preserved traces of animals or plants,<br>E.g. footprints, burrows or rootlet traces. | Science Plus Bk. 1 Page 16:Formation of fossils.<br>AQA GCSE Science page 72 and 73.<br>How fossils were used as evidence of whale evolution:<br>www.pbs.org/wgbh/evolution/library/11/2/e_s_3.html<br>Information on how to make a fossil cast;-<br>www.hometrainingtools.com/articles/make-fossils-cast-science-project.html<br>The chemical process of fossilisation;<br>Dissolve 500cm3 of sugar into 150cm3 of water, using a Bunsen burner to gently heat the water so the sugar dissolves.<br>Allow solution to cool for 15 min.<br>Drop in sponge and leave for 1 week.<br><br>Images of animal fossils<br>http://library.thinkquest.org/J0112517/fossils.htm<br>http://www.science.ca/scientists/viewactivity.php?aID=20<br>Images of plant fossils<br>http://www.lib.utexas.edu/books/landscapes/publications/txu-oclc-4171875/figures/txu-oclc-4171875-a-316a-p-39-400.jpg<br>http://www.fossilmuseum.net/plantfossils/Sapindopsis-anhouryi/Sapindopsis.htm<br>Variety of fossil images<br>http://www.nasmus.co.za/PALAEO/jbotha/photo.htm |

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| 1 Core | Pupils to brainstorm reasons that may cause animals to become extinct. In small groups they discuss these reasons.<br>Pupils look at the mass extinction that took place during the Mesozoic era and relate to modern day animals and plants that face imminent extinction. | **HL**<br>Evaluate responses on a concept map. | To realise the extinction of species.<br>Species may become extinct: if the environment which they need to survive changes;<br>because of successful new predators, new diseases or competition. | Extinction alert for 800 species:<br>http://news.bbc.co.uk/2/hi/science/nature/4522044.stm |
| 1 Extension | Visit local zoo to collect information on endangered species. Data to include the animals origin, natural habitat and why species are now endangered. | Project work linking human activities and endangered species. | Explain the role of mans' activities in bringing about extinction and also in creating conditions for survival of endangered species. | World wildlife fund, the living planet:<br>http://www.wwf.org.uk/core/ |
| 1 Extension | Debate the evolution of man. This could include how the existence of mini man (Flores) could disagree with religion by putting man firmly in the animal kingdom and not above it. | LL<br>Students prepare a debate on the origins of life. Consider the persuasive language used. | Summarise the origins of life, explaining all current evolutionary theories. | Newspaper articles on the discovery of the Flores man:<br>www.nature.com/news/specials/flores/index.html<br><br>www.guardian.co.uk/international/story/0,,1337643,00.html |

**Topic: The Dynamics of Ecosystems**

**Assumed knowledge from previous years**

Biotic and abiotic factors in an ecosystem.
Role of the living beings in an ecosystem- producers, consumers, decomposers.
Food chains and food webs.

**Contents:**

1 Ecosystems and their interactions.
2 Food chains and webs.
3 Influence of abiotic factors. Land and aquatic ecosystems.
4 Influence of biotic factors. Ecological successions and soil formation.
5 Population growth and its limiting factors. Pests and biological control.
6 Competition.
7 Adaptations.
8 Energy flow and circulation of materials.
9 Environmental issues.

Total number of lessons for this module: 10-12 core + 3 extension.

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
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| 2 Core | Ecosystems and their interactions. Food chains and food webs.<br>As a starting activity, explore previous knowledge about ecosystems with a practical exercise: taking the classroom as an ecosystem, encourage the students to write down the biotic and abiotic factors that form it. Work through their answers as a class and then revise basic definitions such as biotope, biocenosis, community, population or habitat. These definitions can be revised using a PowerPoint.<br>What factors affect communities?<br>Use OHP to show in a schema that the distribution of organisms in an ecosystem is affected by multiple factors- physical factors, biological factors (e.g. competition, adaptations and predator-prey interactions), as well as by human activity. All these factors will be looked at in-depth throughout the block.<br>The living beings in an ecosystem therefore interact with each other, being the most important interactions the ones based on nutrition i.e. the trophic relationships. Can they remember from previous years the different trophic levels in food chains and webs? Revise the role of producers, consumers and decomposers and then illustrate these terms presenting an example of a food chain and a food web with the OHP. | Gap-filling activity with key-words like population, community, biotope, habitat, producer, consumer, decomposer, parasitism, predation...<br><br>Make them work on a model food web to identify in it different food chains, classify the living beings according to their trophic level and work out how the disappearance of a particular species would affect the whole ecosystem. | An ecosystem includes all the living organisms that interact with one another and also with the physical and non-physical factors present.<br><br>Differentiate the biotic and abiotic factors in an ecosystem.<br><br>Students know populations of organisms can be categorised by the functions they serve in an ecosystem. | OHP for schema and diagrams of food chain and food web.<br><br>MacKean Biology p. 224-226 (revises food chains and food webs, as well as the trophic levels).<br><br>Video or DVD with documentary showing populations interacting in their natural habitats. Alternatively, pictures can be printed from the internet.<br><br>www.worldofteaching.com (contains free PowerPoint presentations and notes on ecosystems with basic definitions like the components of an ecosystem).<br><br>Other webs:<br>www.bbc.co.uk/schools/gcsebitesize/biology/livingthingsenvironment<br>(has a link to revision notes and on-line test questions on feeding relationships, food chains and food webs). |

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| | Discuss different types of trophic relationships between populations (parasitism, symbiosis, predation,..) making sure they understand the benefits/prejudices for/to the populations in each of the cases. A video, DVD (ex-National Geographic) or pictures can be used at this point to get the students to work in groups and challenge them to identify different trophic relationships in them.<br><br>OR:<br>Students work in groups to elaborate posters that illustrate different types of trophic relationships. | Students fill out a chart with the main characteristics and some examples of different types of trophic relationships.<br><br>Assess elaboration and presentation of poster. | There are different trophic relationships between members of a community.<br><br>Effects of the removal of one species on the remaining organisms in a food web. | www.vtaide.com/png/foodchains.htm (the students can revise here the trophic levels and then create their own food web in different ecosystems- desert, forest, rainforest... could be done at home to help introduce the following lesson-aquatic and land ecosystems). |
| 1 Core + 1 Extension | Abiotic factors- Land and aquatic ecosystems.<br>Discuss different examples of aquatic and land ecosystems-woodland, moorland, pond,...<br>Challenge the students to write down what sort of abiotic factors are different between them, and in what ways they affect the organisms that live in a particular place. Discuss their answers in a plenary session, ensuring that the influence of factors like water, light, and temperature are made clear.<br>The students can then work on an activity where they get two pictures of a land and an aquatic ecosystem and they have to answer questions like:<br>Where does the light come from in each case?<br>Is it propagated better through the atmosphere or through water?<br>How does this affect the distribution of plants in aquatic and land ecosystems? (cont.) | Assess their answers about the land and aquatic ecosystems. | Students identify food webs in different land and aquatic ecosystems.<br><br>Abiotic factors might influence the distribution of organisms in an ecosystem. | Pictures/diagrams of land and aquatic ecosystems.<br><br>www.arkiveeducation.org (The Support Materials link contains pdf files with notes on different land and aquatic ecosystems like woodlands, moorland, coniferous forest, freshwater habitats ,..) |

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| | Is the oxygen equally available in both ecosystems?<br>Does this condition any type of adaptations in the respiratory surfaces of aquatic and land animals? (The topic of adaptation will be dealt with later, but this might serve as an introduction).<br>Which animals will need to develop larger respiratory surfaces?<br>Which living beings- aquatic or land- suffer more the effects of gravity and therefore need to have structures for support?<br><br>Extension: It would be advantageous if there is access to a local pond so that pupils can experience pond life first hand and place their learning into a real life context. If there is, they can collect some weeds, tadpoles and water beetles from a local pond or stream and put them in a large-size coffee jar. What different feeding relationships can they identify? What would happen if the tadpoles were removed from the jar? And if we removed the weeds?...<br>OR:<br>An ICT extension activity could be the investigation of a virtual pond, with activities to gain a real insight into freshwater environments. For this, they can visit the Hams Hall Pond (see Resources). | Assess the collection of data and presentation of results from their investigation. Are they able to draw conclusions from their own data and use evidence to back them up? | | The Hams Hall pond activity from the internet<br>provides the opportunity to investigate a virtual pond and learn more about freshwater ecosystems: www.bgfl.org/bgfl/custom/resources_ftp/client_ftp/ks3/science/hamshall/index.htm<br><br>Another web which might be worth visiting: www.english-nature.org.uk/science/nature_for_schools/secondary_1.asp (has a link to a download document called “Marine ecosystems” where marine ecosystems are compared and contrasted with terrestrial ecosystems and some activities are proposed). |

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| 1-2 Core | Successions and soil formation.<br>Refer back to the abiotic factors that affect the distribution of organisms and remind the students that one organism's distribution is also related to the way another organism is distributed. This fact is illustrated in an ecological succession.<br>Tell the students to imagine they have an area of bare soil, and they leave it entirely alone. Challenge them to describe what sort of populations would start to grow first, which next and so on (grass and weeds small bushes shrubs small trees large trees); this illustrates a primary ecological succession.<br>To help them understand the difference between a primary and a secondary succession (new ecosystem develops after an existing one is disturbed), the students could think of the following situation: what sort of population changes would occur in a wood where a fire has destroyed part of the canopy which shades out plants beneath?<br>Point out to students that as plants gradually develop on a particular place, the soil also develops, so that both increase together. Explain what soil consists of with the help of a cross-section diagram of a piece of soil, and how it is formed with the joint action of weathering, erosion, deposition and the action of the living beings that grow in it. Challenge them to suggest ways in which earthworms and plants can help to improve the soil. | Fill in the gaps activity with terms like primary and secondary succession, pioneer plants, climax, humus, weathering, erosion.<br><br>They are able to put in the correct order different pictures that illustrate the stages of soil formation and label them correctly. | Students know that ecosystems change over time so that some populations prepare the habitat for others to move in.<br><br>They distinguish between primary and secondary successions. | www.s-cool.co.uk/topic_principles.asp?loc=pr&topic_id=4&subject_id=3 (contains links for revision of different ecological concepts. One of the links is to ecological successions and it contains very interesting notes and examples of primary and secondary successions, as well a revision of terms like pioneer species or climax community).<br><br>www.biologycorner.com/worksheets/succession.html (interesting on-line activity in which the students have to place the stages of succession of two ecosystems into sequence. Also have to describe changes in an ecosystem and make predictions about changes that will take place from one stage of succession to another). |

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| | So that they understand what humus is and its beneficial effect, the students can carry out a simple investigation at home: They obtain some good garden topsoil and describe it as fully as they can. Some of the particles may be separated, but others are clumped together into soil crumbs. If they put a soil crumb on a sheet of paper and squash it with their finger- what do they think makes the particles stick together? What causes the soil to cling to the roots of a plant which has been pulled out of the soil? Soil crumbs make the soil better for plant growth- why? Finally, they can make a list of all the features of the soil they can think of which, directly or indirectly, help plants to grow in it. | Assess if the students can draw conclusions from the soil crumbs investigation. | They know what the soil is formed of and that the living beings that grow in it play an important role in its improvement (e.g. turning it over, fertilising it) and in holding it together (e.g. plant roots). | Absolute Science Pupils Book 2 pg. 145-147 has information on how soil is formed from rock particles and what soil contains.<br><br>www.kswheat.com/upload/Exploring1.pdf ( notes on how soil is formed and how it is lost, soil building factors. It also has activities that can be carried out by the students, like a composting activity). |
| 1-2 Core + 1 Extension | Population growth. Pest control.<br>How do populations grow? Show the students a picture of an ideal population growth graph (S-shaped graph) and get them to draw conclusions from it, e.g. why are there different sections in the graph, why might the population rise so quickly in one part of the graph or what can make the growth curve eventually flatten out (i.e. what limiting factors prevent the population from growing indefinitely). They can then work on a particular example, e.g: Can they suggest some abiotic and biotic factors that might prevent an increase in the population of sparrows in a farmyard? | Label the different sections of a population growth curve (lag phase/ log phase/s-phase/ stable phase). | They can explain the growth curve of a population under ideal conditions.<br><br>They know which are the limiting factors in population growth. | OHP to show an ideal population growth curve and a graph with predator-prey relationships.<br><br>MacKean Biology Ch.29 Population growth and factors affecting populations.<br>The classical example of the fluctuating populations of lynxes and snowshoe hares in Canada can be found in MacKean Biology pg. 260. |

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| | Populations are naturally controlled by their predators.<br>Present them different examples of predator-prey systems, like the classical example of snowshoe hares and lynxes, or the case of the Kaibab deer. Get the students to think about the type of interdependence between both populations (predators and prey) and how the growth of one of the populations affects the numbers of the other population e.g. if predators are numerous then more prey is caught; if prey is scarce, then some of the predators will starve.<br>Can they think of any example where a population could grow without stopping and what sort of effects this has on agriculture or on the environment? This example might be used to illustrate what pests are. Tell them about what happened after the introduction of rabbits in Australia.<br>Ask them to think about natural or artificial approaches to biological control of pests. (natural: predators, disease; artificial: deliberate introduction of disease e.g. myxomatosis to kill rabbits, poisoning) and write a report about it. A particular example can be suggested e.g. Suppose that a certain island becomes overrun with rabbits. Suggest three different ways by which people living on the island might try to reduce the rabbit population. Briefly mention the advantages and disadvantages of each method. **LL** and **GL.**<br>Extension: ICT activity "Deer: Predation or Starvation" OR they can see a predator-prey simulation (see Resources). | They interpret a predator- prey graph, in terms of the interdependence between the two populations.<br><br>Assess their report on pest control. | The distribution and relative abundance of organisms in habitats can be explained using ideas of interdependence and predation.<br><br>The students know which are the main approaches to the biological fight of plagues.<br><br>Plagues are related to agricultural and environmental issues. | Webs:<br><br>The lesson of the Kaibab deer: www.biologycorner.com/worksheets.php (There's a link too to the activity "Deer: Predation or Starvation", which is a graphing exercise that compares predator and prey populations on an island).<br><br>http://home.messiah.edu/~deroos/CSC171/PredPrey/PPEx5.htm (has a rabbits-foxes simulation)<br><br>http://www.biotopics.co.uk/eco/maneco.html (contains a detailed explanation of what biological control is and gives a few examples of mechanisms of control of target pests).<br><br>Two FAO web pages can be used by the students to learn more and pick out ideas for their report:<br><br>www.fao.org/newsroom/en/focus/2006/1000345/index.html (it is an article about the biological control of locusts).<br><br>www.fao.org/ag/locusts/en/info/info/index.html (has info about locusts and other migratory pests groups). |

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| 2 Core | Competition. Adaptation.<br>To introduce the topic of competition, explain or read to the class an example of two competing species- the red squirrel and the grey squirrel, whose population grew dramatically throughout the 20th century in the UK, at the expense of the former species. Make the students discuss why they think the grey squirrel population has increased like this, while the red squirrel has declined. (Limited food resources leads to competition, and the species which is better adapted proliferates).<br>Competition is therefore another factor that limits population growth. Ask them to think about examples of resources that individuals compete for, both between individuals of the same species (intra-specific competition) and between individuals of different species (inter-specific competition). They can then work in groups with pictures of competing species and they fill in a chart- type of competition? What is the resource that leads to the competition? What adaptations to the habitat can they identify?<br>Other examples of adaptations can be discussed, like cacti which are adapted to hot arid environments, or polar bears to extremely cold environments. They can produce a poster in groups with pictures of an organism they choose and they explain the different adaptations that this living being has in order to survive and carry out its role in that environment (see Resources). | They identify competition for different resources from pictures and fill out a chart with the specific characteristics of that competition (intra/ interspecific, what resource they are competing for).<br><br>They judge from pictures what features of a particular organism might be adaptations to their respective habitats or way of life. | The distribution and relative abundance of organisms in habitats can be explained using ideas of competition and adaptation.<br><br>Adaptations are changes in an organism, in the course of evolution, which help to make it more successful in its habitat.<br><br>There is competition within and between species for food, light, space and mates.<br><br>When living beings compete, the ones with the best adaptations are most likely to win. | http://www.s-cool.co.uk/topic_principles.asp?loc=pr&topic_id=4&subject_id=3 (one of the links is to ecological concepts about populations- we can find detailed explanations about how populations increase in number over time as well as what factors affect population density. Competition is explained in-depth).<br><br>www.uen.org/utahlink/activities/view_activity.cgi?activity_id=4750 (this page from the Utah university invites the students to sample several internet sites about animal adaptations and complete the activities for each one, to find out for e.g. how a koala's paws are adapted for life in a tree. Students may find it useful for picking out ideas for their posters). |

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| | Extinctions:<br>Remind them that species may die out (become extinct) because of the harmful effects of human activities on the environment. Natural extinction also happens through competition between species or changes in the environment, as some species may not be able to adapt to their new environment (Link with block on Heredity and Transmission). Tell them about the extinction of the dinosaurs which occurred about 70 million years ago and which made way for mammals and birds to fill the vacant spaces in the environment. **HL**. | Assess poster production and their presentation to the class- are they able to identify adaptations and explain to the class how they contribute to the survival of a particular species? | | Hodder Murray EDEXCEL GCSE Science has a text on pg. 6 concerning the competition between red squirrel and grey squirrel populations. Alternatively,<br>the text can be looked up in the internet.<br><br>McKean Biology pg. 254-257 (Competition and adaptation-the topic of adaptation is explained through a couple of examples: camels and polar bears. The adaptation of plants to arid conditions can be found on pg. 61-62). |
| 1 Core | Energy flow and circulation of materials.<br>How does energy enter an ecosystem?<br>Discuss with the students that the energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food chains. At each link in the food chain, energy is lost in the waste products produced by organisms and as a result of the metabolism, mainly in the form of heat. Ecological pyramids represent this energy flow. OHP or PowerPoint presentation can be used to show these pyramids and discuss with the students what they represent. For example, after seeing a typical pyramid of numbers where the producers are most abundant, we could make them think of a situation where the pyramid could be upside-down (e.g. one large tree supporting many herbivores, or many parasites feeding on fewer primary consumers,..). | They interpret pyramids of biomass and numbers.<br><br>They answer questions about the carbon cycle, like: What is photosynthesis and how does it remove carbon dioxide from the atmosphere? What is respiration, and how does it add carbon dioxide to the atmosphere? (cont.) | Understand that energy is transferred along food chains and is lost at each trophic level, whereas matter is recycled thanks to decomposers.<br><br>The students can interpret pyramids of numbers and biomass and know that the best picture of the relationship between producers and consumers is given by the pyramid of energy. | OHP to show energy flow charts and material cycles, as well as different examples of pyramids of numbers, pyramids of biomass and pyramids of energy.<br><br>MacKean Biology pg. 227-232 (C and N cycles, Energy flow).<br><br>http://regentsprep.org/regents/biology/units/ecology/index.cfm (contains online revision notes and multiple choice questions about different topics related to the environment, e.g. Material cycles and energy flow). |

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| | On the other hand, pyramids of energy can never be upside-down because of the energy loss along the food chain.<br>Materials circulate in the ecosystems:<br>Use OHP to explain the material cycles. We can then provide a schema of the carbon and nitrogen cycles where the names of some processes have been rubbed off (photosynthesis, respiration, decay,…) and challenge the students to label them. The role of decomposers is revised and reinforced through this activity.<br>As homework, the students could write a short report on why being a vegetarian is not a bad idea from the energetic point of view. (Being a vegetarian shortens the food chain and reduces the loss of food energy between trophic levels. Output therefore increases). | Name the main kind of organisms that bring about decay, and explain how they put carbon dioxide into the atmosphere.<br>What happens chemically when coal is burned?...<br><br>They label a nitrogen cycle diagram with the names of the 4 types of bacteria that take part.<br><br>Assess scientific content of their report .**LL** and **GL.** | | www.marietta.edu/~biol/102/ecosystem.html (more notes on the biogeochemical cycles).<br><br>www.science-interactive.co.uk/samplelessons.htm contains a PowerPoint about the flow of energy and elements through the ecosystem which could be used to explain concepts like the pyramids of number, biomass and energy as well as to review previous concepts from the unit.<br><br>www.skoool.co.uk : Keystage 4 Biology has an interactive presentation (#8) which covers the flow of energy through living systems and can also be used to revise previous concepts like the growth and distribution of populations or adaptations. |
| 2 Core + 1 Extension | Human impact on the environment:<br>Encourage discussion about how the growth of the human population in the last 300 years has had an impact on the environment. Use their answers to highlight the following issues:<br>Human impact on natural communities:<br>Hunting and over-fishing: Tell them for e.g. that WWF believes that 15-20% of all species on Earth will soon disappear if we do not change our patterns of consumption and destruction. This is 1000 times faster than the natural extinction rate. | | | OHP to show DDT accumulation along a food chain (e.g. flow diagram in Collins Absolute Science Pupil Book 3, pg. 139. DDT is discussed ). |

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| | Use of pesticides: Nowadays pesticides are biodegradable, however not so long ago they were persistent. Discuss the case of DDT, which was widely used in UK between 1940s-1960s, but was found to affect various bird populations in different ways and finally banned. However, DDT is also used to fight malaria in poor countries, this gives rise to a conflict between environmentalism and human health. Challenge the students to think about advantages and disadvantages of the use of DDT and write a report giving their opinion. A debate on benefits/hazards of use of pesticides vs. biological control can also be held.<br>Deforestation:<br>Discuss the main reasons and consequences (climatic changes, reduced soil fertility and soil erosion, flooding and landslide, destruction of species) of deforestation. Ask them to write a report explaining what is meant by the term deforestation, suggesting ways in which deforestation might affect the number of species living in a particular area and describing two other ways the environment is changed by deforestation.<br>Then give them the following instructions to produce a Campaign poster in groups: A local council is planning to build a new road through the middle of an area of old woodland which contains rare plants, rare butterflies and a few deer. They have to show in a poster why the road should be built around the wood and not through it, using illustrations to add interest. | Work on a food web and answer questions like, e.g., Explain how using a pesticide to get rid of the slugs could affect the food web.<br><br>Assess their report on Pro's and Con's of using DDT to fight against malaria. **LL** and **CiL.**<br><br>Assess their report on deforestation. . **LL** and **GL.**<br><br>Content and presentation of campaign poster. **CiL** | Students know how pesticides can affect food webs.<br><br>They know the main reasons why people exploit forests and understand the problems which result from deforestation.<br><br>They are able to evaluate and critically analyse the effects of human interactions on natural populations and ecosystems.<br><br>They understand the importance of a correct management of ecosystems. | www.acsh.org/healthissues/newsID.442/healthissue_detail.asp (article from the American Council on Science and Health about the DDT ban and its effects on the fight to control malaria).<br><br>http://www.s-cool.co.uk/topic_quicklearn.asp?loc=ql&topic_id=4&quicklearn_id=7&subject_id=3&ebt=&ebn=&ebs=&ebl=&elc= (contains notes on deforestation- its reasons and consequences).<br><br>www.mongabay.com (has a link to rainforest information, also with a section for kids).<br><br>Hodder Murray AQA GCSE Science pg. 46-47 (deforestation).<br><br>MacKean Biology unit 26 (This chapter is about human impact on the environment).<br><br>Hodder Murray AQA GCSE Science pg. 49-52 (presents different approaches to reduce damage to the environment). |

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| | In a previous lesson we have asked them to look up information (from newspaper articles, from the internet,…) about other environmental problems such as the greenhouse effect, global warming and climate change, acid rain,…Encourage a discussion in class and ensure that they understand the meaning of the above terms, how they are produced and what their consequences are.<br><br>Extension: What can each of us do to reduce damage to the environment?<br>Brainstorm for ideas/ suggestions and write them down on the blackboard for discussion (e.g. making our homes more energy-efficient, reusing materials and recycling waste,..). Tell them about sustainable development .Then make them work in small groups to decide what each of us can do for a better future and present their conclusions/ suggestions in a poster (AQA GCSE Science activity pg. 51) . | They complete a summary chart with the main environmental problems, what they consist of, how they are produced, what their consequences are.<br><br>Assess poster about their plan for a better future, and how they present it to the rest of the class. CiL. | Students understand what global warming, greenhouse effect, climate change and acid rain are, as well as their causes and their effects.<br><br>Students should be able, when supplied with appropriate information, to use their scientific knowledge, weigh evidence and form balanced judgements about some of the major environmental issues facing society.<br><br>Sustainable development is necessary to make sure that fuel, food and a pleasant environment are available for future generations. | www.nerc.ac.uk (has a link to environmental issues like climate change or the pressures on biodiversity- habitat loss, invasive species, pollution and waste, over-exploitation,…might be interesting for the students to read).<br><br>www.recyclezone.org.uk (information about recycling, reducing and reusing. Also activities, lesson plans and fun games).<br><br>www.skoool.co.uk : Keystage 4 Biology has an interactive presentation (#7) which covers some of the issues dealt with in these lessons (use of pesticides, greenhouse effect, eutrophication,..) as well as the role of conservation on the environment.<br><br>www.s-cool.co.uk/default.asp<br>(the link Biology GCSE Environmental problems has guidelines for revision, a summary and on-line questions on environmental problems). |

# Geology

## Topic: The Earth, a Planet in Continual Change. (The History of the Earth)

### Assumed knowledge

Planet Earth and the Solar System.
Rocks – Sedimentary, metamorphic and igneous rocks.
The rock cycle.
Structure of the Earth's layers.
Transport in rivers.
Earthquakes.
Fossils.
Crystallography.
The effects of weathering.

### Contents

1. The origin of the Earth.
2 Geological time.
3 Historical ideas about the age of the Earth.
4 Principles and procedures that enable us to reconstruct our history.
5 Using the present to see the past.
6 Fossils and their importance as a testament to the past.
7 Geological eras/periods.
8 The first living beings and their influence on the planet.
9 Basic reconstruction of history of your local area through a simple stratigraphic column.

Time for this module 18 lessons and 2 extensions.

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
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| | The origin of the Earth.<br>Question pupils to find out how much they know about the origin of planet Earth, the Solar System and the Universe. Previous work on the Earth and its position in the Solar System could be revised. Questions may include:<br>What units do we usually use to measure time? What units do geologists use to measure time? Why is early Earth history (Precambrian) more difficult to decipher than more recent geological history? How old do you think the universe is? How old is the Earth? How old is the moon? How old is the Solar System? Has the Universe always existed or did it come into being in a particular moment in time?<br><br>Briefly explain the Big Bang Theory to the students and what led scientists to believe that the theory is correct. Explain how the Earth was formed some 4.6 billion years ago using diagrams.<br><br>Read and discuss section, 'The Solar System Forms' from 'From the Beginning' book . | Students should be able to give a written account of the Big Bang.<br><br>Written account of how the Earth and Solar System were formed using diagrams. | The Universe began with a Big Bang approximately 15-20 billion years ago. Astronomers have deduced this age from the fact that celestial objects are moving away from each other in what appears to be an ever expanding universe.<br><br>The background radiation of 2.7degrees above zero is thought to be the faint afterglow of the Big Bang.<br><br>Understand the current theory of the origin and early history of the Solar System (nebular hypothesis). | BBC book "Earth Story – The Forces That Have Shaped Our Planet" by S. Lamb & D. Sington, Chapter 8 which includes diagram showing birth of Earth in the Solar System.<br><br>Accompanying DVD Earth Story. Chapter 8 "A World Apart".<br><br>Sections from the following books may be used for their accounts of the origin and early history of the Earth:<br><br>Essentials of Geology by FK Lutgens & EJ Tarbuck. Chapter 19 Earth History: A Brief Summary. This book also has a webpage at http://www.prenhall.com/lutgens/<br><br>"From the Beginning" book by K. Edwards and B. Rosen. Section on page 4 "The Solar System Forms" and "Early Earth" page 8. |

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| Core | Reassemble text on origin and early history of Earth. Give students an envelope with a suitable text which has been cut into separate pieces. There should be enough clues in each separate piece for it to be possible to connect them in a logical sequence (e.g. a clear chronological sequence). Students can work on their own or in pairs to reassemble the text to make a finished product from the various bits and pieces. Discuss students' ideas and go over answers.<br><br>Read section in chapter 19 on "The Origin of the Earth" in Essentials of Geology book.<br><br>Show 5 minute clip of the early Earth in 'Earth Story' DVD.<br><br><u>2 Geologic Time</u><br>Many students have difficulty in appreciating the immensity of geologic time. In order to help overcome this, the teacher could begin by making sure that the pupils know how big a million is and how big a billion is. | Try internet 'concept quiz 1` Earth History – A Brief Summary on the Essentials of Geology Website. | The decay of radioactive elements and heat released by colliding particles aided the melting of Earth's interior, allowing the denser elements, principally iron and nickel, to sink to its centre and the lighter elements to float to the crust. As a result of this differentiation, Earth's interior consists of shells or spheres of materials, each having distinct properties.<br><br>Pupils should know what the geological timescale is and what are its principal subdivisions. | For the more capable students: "Physical Geography" by JS Monroe & R Wicander, Chapter 20 " A History of the Universe" (section on Current Theory of the Origin and Early History of the Solar System).<br><br>Article on Earth / History of Earth can be found at http://en.wikipedia.org/wiki/Earth<br><br>Internet concept quiz from Essentials of Geology website can be found at http://www.prenhall.com/lutgens/ There are some useful activities in editions 8 an 9 of the book.<br><br>How big is a billion? Some useful teaching suggestions can be found at University of California online exhibits website: http://www.ucmp.berkeley.edu/education/lessons/billion/billion.html. This site also contains lesson ideas for teaching Geological Time. |

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| Core | Maths activities using millions and billions.<br><br>Ask students how geologists subdivide the massive units of geological time. Put the following units of time in order from smallest to largest: Eon, Era, Period and Epoch.<br><br>Provide students with a year calendar asking them to compare Earth's history (4,600 million years) with one year. Mark the important events in the Earth's history compressed into one year. (**NL**)<br><br>Convert the above calendar to compare geological time with a 24 hour period instead of a year. This means each minute would be equivalent to 3.2 million years (**NL**).<br><br>Alternatively the class could Compare Earth time with a one hour clock marking the key events.<br><br>Use timelines to mark in important geological or biological events.<br><br>Make your own geological clock. | Mathematical questions converting Earth history into a one hour period or 24 hour period. | Pupils should know what the geological timescale is and what are its principal subdivisions.<br><br>The geological column provides a means of placing geological events in their correct time sequence and in defining the absolute age of some events. | http://www.ucmp.berkeley.edu/education/lessons/billion/billion.html. This site also contains lesson ideas for teaching Geological Time.<br><br>The book Geology-A Self Teaching Guide, Chapter 3, The Rock Record and Geologic Time contains useful information on geologic time.<br><br>An image search on 'Geological Clocks' should provide many suitable visual aids for teaching this topic.<br><br>Earth Story DVD and book, Chapter 1 – The Time Travellers.<br><br>"Understanding Geology" book by David Webster chapter nine Geological Time. |

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| Core | Complete activities in chapter 9 of Understanding Geology.<br><br>Present students with an image of the geological column on a whiteboard. Explain some of the major geological and biological events that have happened (e.g. earliest fossil record of life, the first fish, the first plants, the formation of Pangaea, the extinction of the dinosaurs, the earliest humans etc). Stick labels or write the key events onto the board matching them to the approximate time of their occurrence. The pupils could be given ten or twelve minutes to study the chart. The image and labels can then be removed from the board. The students could then be given envelopes containing a geological column and say ten or twelve cut out labels of the key biological / geological events. They then have to reassemble the Geologic Column matching up the key biological/historical event with the corresponding date. Once they have the correct order they can stick the completed chart in their books. | Fill in an incomplete version of the Geological Column.<br><br>Labelling activities to match key biological/ geological events with correct time period. | Students should be able to situate the major geographical, biological and geographical characteristics of each period within the correct time frame. | The English version of the Santillana Book, “Science 4 Biology & Geology” Chapter 3 “History of the Earth & Life”. This contains a useful table summarising the unit which could be blown up in size and used to describe the main biological and geological events in Earth’s history.<br><br>The Geologic Column in the book “Physical Geology- Exploring the Earth” (Chapter 8 Geologic Time by JS Monroe & R Wicander can also be used for this activity) as it has a list of the key biological and geological events. |

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| | Show students a visual representation of the Geologic Column. Very briefly explain the history of the making of the timescale and the standard names used world-wide for each of the different sections in it. The origin of the names could also be noted, e.g. “Hadean” comes from the Greek meaning ’Beneath the Earth’, “Archean” means ’ancient ‘ etc.<br><br>Give pupils five or ten minutes to learn the names of the different sections of the Geological Column. Remove the image from their sight. Issue them with a blank geological column (or partially blank column) and ask them to complete it, filling in the spaces of the relevant Eons, Eras, Periods, and Epochs. | Match names of eons or periods with their dictionary/ etymological definitions.<br><br>Completing blank or partially blank geological columns. | Through the efforts of many geologists applying the principles of absolute and relative dating, a geological timescale has been established.<br><br>Students should be able to distinguish between the different stages of the evolution of the planet Earth. | University of California Museum of palaeontology webpage contains section on the history of the geologic timescale http://www.ucmp.berkeley.edu/exhibit/histgeoscale.html<br><br>Article on internet by WL Newman on geological time www.2.lib.udel.edu/subj/geol/internet.htm<br><br>For a more detailed reference including information on the history of the timescale see the wikipedia article under Geologic Timescale http://en.wikipedia.org/wiki/Geologic_timescale |

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| Core | 3 <u>Historical ideas about the age of the Earth</u><br>Research information from books or the internet on the individuals below and their contributions to the finding of the age of the Earth.<br><br>Prepare talks, power point presentations or fact files on the contribution these people have made to finding the age of the Earth.<br><br>Archbishop James Usher's attempt in the 1650's to date the origin of the Earth using the book of Genesis from the Bible. Provide students with examples of the genealogies that were used from the Bible:<br>Nicolaus Steno and his principles<br>John Woodward's fossils;<br>James Hutton's observations (Hutton's unconformity);<br>Charles Lyell and uniformitarianism<br>William Smith-the canal engineer, and his principle of fossil succession;<br>Darwin's theory of evolution and its influence;<br>Lord Kelvin and his attempt to determine age of earth using heat loss calculations. | Assess power point presentations or talks on scientists who made contributions to finding the age of the Earth. | Know that the concept of geological time and Earth's age changed through human history.<br><br>Students should understand that throughout history many different theories about the age of the Earth have been put forward.<br><br>Pupils should be able to distinguish between religious and scientific theories and be able to give reasoned answers as to why some theories may offer a better explanation than others. | Article on internet by WL Newman on geological time<br>http://pubs.usgs.gov/gip/geotime/contents.html<br><br>Bible Genesis, Chapters 4,5 & 11.<br><br>University of California Museum of Palaeontology webpage contains section on the history of the geologic timescale<br>http://www.ucmp.berkeley.edu/exhibit/histgeoscale.html<br><br>Historical Geology Book, Chapter 4, Geologic Time: Concepts & Principles by R Wicander & JS Monroe. |

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| Core | Wegener and his ideas on continental drift<br>Pierre and Marie Curie's discovery that radioactive decay produces heat<br>Ernest Rutherford and the discovery of radioactivity and later radiometric dating techniques.<br><br>Show section of Chapter 1 Earth Story DVD.<br><br>4 <u>Principles of historical geology</u><br>Explain the principle of uniformitarianism (the present is the key to the past). Show short section of Earth Story DVD to look at ideas of James Hutton.<br><br>Explain the difference between relative and absolute dating. Complete Earth Science Homework Helpers activities.<br><br>Interpretation of diagrams showing faults, folds, unconformities. Show examples detailing the concepts of original horizontality, continuity and superposition of strata (or if possible field work).<br><br>Read Essentials of Geology, Chapter 18, Geologic Time. Complete the relevant questions for review at the end of the chapter. | Self assessment activities from Earth Science Homework Helpers book, chapter 6, Geologic History. This contains exercises on absolute & relative time. It also deals with the concepts of original horizontality, continuity and superposition of strata. | Geological events can be placed in relative time scales using criteria of relative age: evolutionary change in fossils, superposition of strata, unconformities and cross cutting relationships.<br><br>Students should be able to explain and distinguish between relative and absolute dating of rocks. | Earth Story BBC DVD and book. Chapter one "The Time Travellers." Simon Lamb and David Sington.<br><br>"Earth Science Homework Helpers" by Phil Medina. Chapter Six.<br><br>"Geologic History" contains exercises on absolute time and relative time as well as diagrams detailing concepts of original horizontality, continuity and superposition of strata.<br><br>"Geology – A Self Teaching Guide" Chapter 3 "The Rock Record and Geologic Time" covers the principles of stratigraphy and fossil correlation and includes self test questions at the end of the chapter. |

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| Core | Try some of the online activities from the Essentials of Geology Website.<br><br>Simple analysis of decay curves and half life concept.<br><br>Imitate the decay of radioactive elements by tossing a large number of coins. Remove any heads and count how many tails are left. Repeat the process until only a few coins are left. The discarded head coins represent atoms that have decayed. Plot results on a graph using the vertical axis to show how many tails are left after each throw and the horizontal axis to record the number of throws. Compare the graph with the figure 9.6 in Understanding Geology book by David Webster.<br><br>Laboratory or modelling experiments to produce different types of unconformity.<br><br>Simple calculations of mineral age based on half life concept. | Analysis and interpretation of half life graphs, **NL**<br><br>Simple calculations of mineral age using half life concepts. | Some rocks & minerals can be dated radiometrically to give an absolute age: radioactive half life concepts; radiometric dating.<br><br>Unconformities as hiatuses in the geological record.<br><br>Formation of unconformities by Earth movements. | A more demanding text would be: "Historical Geology" by R Wicander & JS Monroe. Chapter 4 Geologic Time: Concepts & Principles. This book also contains questions at the end of the chapter and a book companion website http://earthscience.brookscole.com<br><br>Essentials of Geology book by FK Lutgens & EJ Tarbuck, Chapter 18, Geologic Time. Section on "Dating With Radioactivity".<br><br>Concept Quizzes on internet on chapter 18 of Essentials of Geology webpage can be found at http://wps.prenhall.com/esm_lutgens_essentials_9/ |

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| Core | <u>5 Fossils and their importance as a testament to the past</u><br>Bring some fossils or pictures of fossils into the class to introduce this topic. Question students:<br>Can you identify this fossil?<br>What exactly is a fossil?<br>Why are fossils important to us and in particular to geologists?<br>Are fossils always the remains of living plants and animals?<br>What types of animals are more likely to become fossils?<br>What parts of animals are likely to become fossils?<br>Do most plants and animals become fossils?<br>In which type of rock are we most likely to find fossils? Why?<br>What types of conditions are suitable for preserving fossils etc?<br><br>Write an accurate definition of what a fossil is.<br><br>Ask students to write down the characteristics of the type of fossil that would help geologists establish the age of a rock. | Matching pictures of fossils to their chronological period or era.<br><br>Written account of the "perfect" fossil for geologists **LL**. | To be able to explain what a fossil is and to be able to evaluate the information we can obtain from fossil remains.<br><br>To observe various fossils and be able to estimate their chronological era and period of existence.<br><br>Fossils are evidence of former life preserved in rocks. They provide information on the nature of ancient organisms.<br><br>The special conditions that favour preservation are rapid burial and the possession of hard parts such as shells, bones or teeth. | From the Beginning book by K Edward & B Rosen Chapter on "What Are Fossils?" page 26.<br><br>"Getting into the fossil record" and "Stories from the fossil record" - PowerPoint presentations and lesson plans in Geological Society of America web page.<br><br>Earth Story BBC DVD Chapter One The Time Travellers – Section on ammonite fossils.<br><br>How do we know evolution happens http://www.pbs.org/wgbh/evolution/library/11/2/e_s_3.html<br><br>Fossils Rocks and Time (US Geological Society) by Lucy E Edwards and john Pojeta Jr http://pubs.usgs.gov/gip/fossils/contents.html<br><br>BBC Science and Nature "Making Fossils" http://www.bbc.co.uk/sn/prehistoric_life/dinosaurs/making_fossils/ |

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| Core | Explain how fossils are made. Read section on The Formation of Fossils in chapter 12 of "Understanding Geology".<br><br>Explain or read Encyclopaedia Britannica article on the story of William Smith, the canal engineer who discovered one of the most important and basic principles in historical geology (the principle of fossil succession).<br><br>Explain why index fossils are of particular use to geologists.<br><br>View section of Earth Story DVD to show how fossil ammonites are used to determine relative ages of rocks.<br><br>Interpretation of evolutionary diagrams.<br><br>Show pupils 5 minute video clip to explain how fossils were used as evidence of whale evolution.<br><br>Show students fossils or pictures of fossils and ask them to suggest what modern day animals may have evolved from them.<br>Use clips from the BBC series" Walking with Beasts" to prompt discussion. | Match modern day animals with their fossil ancestors. | The fossil record provides evidence of changes in flora and faunas through geological time and of the progressive development of higher forms of life.<br><br>Know the principle or law of faunal succession i.e. fossil assemblages (groups of fossils) succeed one another through time in a regular and determinable order.<br><br>Know that the theory of evolution states that all species of living things have evolved from simple life forms which first developed more than 3 billion years ago and that fossils provide us with strong evidence to support the theory of evolution. | Understanding Geology Book by David Webster Chapter 12 (Fossils).<br><br>Article on William Smith the canal engineer from Britannica http://concise.britannica.com/ebc/article-9068306/William-Smith<br><br>Many fossil articles and activities in http://www.nationalgeographic.com/search.html<br><br>Walking with Beasts http://www.abc.net.au/beasts/sitemap.htm |

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| Core | Look at samples or photos of fossils. Appreciate the basic distinctions between fossil groups based on their hard parts and symmetry (brachiopods, bivalves, ammonites, corals and trilobites).<br><br>Use simple keys to identify different fossil groups.<br><br>Complete questions from Essentials of Geology book at the end of chapter 18.<br><br>Complete two or more geological columns with fossils included in them and match the parts which belong to the same age. | Use keys to identify fossils. | Fossils found in only one particular layer of rock all around the world are called index fossils. Index fossils can help us establish the age of rock layers in different parts of the world.<br>Most fossils are found in sedimentary rocks although they might also be found in volcanic ash and volcanic mudflows.<br>Superposition and fossil succession were used to piece together a composite geological column, which serves as a relative timescale.<br>Correlation of biostratigraphic zones show that rocks in different areas, even though they may differ in composition, are of the same relative age. | BBC Science and Nature "Making Fossils" http://www.bbc.co.uk/sn/prehistoric_life/dinosaurs/making_fossils/<br><br>Essentials of Geology book by FK Lutgens & EJ Tarbuck, Chapter 18, Geologic Time. Section on "Fossils: Evidence of Past Life". |

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| Core | <u>6 The Precambrian</u><br>Using the geological column as a visual aid question pupils about the Precambrian :<br>When did it begin? When did it end? What eras make up the Precambrian? Why is our knowledge of the Precambrian more limited than that of other periods? What is Pangaea etc?<br><br>Explain to students using timeline, that the Precambrian extends over an immense geological time period, from the Earth's beginnings 4.6 billion years ago until the start of the Cambrian period, about 4 billion years later. This means that the Precambrian spans about 88% of Earth's history.<br><br>Read section from Santillana book on the Precambrian.<br><br>Explain or use video footage to show the early earth in its molten state. Explain how decay of radioactive elements and heat released by colliding particles allowed melting and the heavier elements, principally iron and nickel sank to the centre, while the lighter rocky elements floated outwards towards the surface. | Possible descriptive writing activity. Imagine that you were in a time capsule and could travel back in time in a spaceship. Describe what you would see in the different periods of the Precambrian. In your answer you could describe the planet from a distance, the climate, the Earth's surface, and any signs of life. **LL** | Pupils should know the main geological, geographic and biological characteristics of the Precambrian.<br><br>Understand the difficulties in ageing rocks from the Precambrian times.<br><br>Know why the fossil fuels are absent from Precambrian times.<br><br>As planet cooled water vapour condensed to form clouds, and great rains commenced to form the oceans.<br><br>The appearance of the first living beings probably bacteria, which did not need oxygen. | Understanding Geology book by David Webster. Chapter 9 Geological Time.<br><br>BBC DVD Earth Story. Time Travellers Chapter 1 contains 5 minute clip of early earth in molten state being bombarded with particles. |

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| Core | Explain that as a consequence of this period of differentiation, gases escaped from the Earth's interior and an atmosphere gradually evolved. Explain that the earth emitted large quantities of water vapour and carbon dioxide along with ammonia, sulphur dioxide, methane, hydrogen and other gases.<br><br>Read chapter 19 of Essential Geology (Earth's Atmosphere Evolves).<br><br>Ask students why we do not have complex fossils from the Precambrian time.<br>.<br>Show pupils photos or video footage of stromatolites, the most common Precambrian fossils.<br><br>Show students video footage of the earliest fossils of bacteria from Earth Story.<br><br>Take UCMP internet tour of geologic time concentrating on the Precambrian era.<br><br>Make a mind map of the Precambrian Era. | Compare the gases in the atmosphere now with those in the early Precambrian. | The first cells were similar to blue greenish algae. They were prokaryotic. Eukaryotic cells came later. They reproduced sexually, exchanging genetic material between organisms. This permits increased genetic variation thus increasing the rate of evolutionary change.<br><br>Later primitive plants evolved that used photosynthesis and released oxygen.<br><br>Microfossils of the most primitive organisms, prokaryotes, have been found, dating the record of life back over 3.5 billion years. | BBC DVD Earth Story Chapter 7 The Living Earth. Contains some excellent video footage on stromatolites in Australia.<br><br>Essential Geology FK Lutgens & EJ Tarbuck Chapter 19. Essentials of geology webpage contains useful chapter summaries and quizzes http://wps.prenhall.com/esm_lutgens_essentials_8/0,6602,237855-,00.html<br><br>UCMP Tour of geologic time can be found at http://www.ucmp.berkeley.edu/exhibits/geologictime.php |

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| Core | 7 The Paleozoic Era<br>Use visual image of geologic column to question pupils about the Paleozoic Era. When did it begin? When did it end? How long did it last etc? Ask pupils to list the seven periods that make up the Paleozoic. Explain why geologists often distinguish between upper and lower Paleozoic Compare pictures of fossils from Paleozoic with those of Precambrian. Question students about the differences. Establish that the beginning of the Cambrian marks an important event in animal evolution. For the first time organism had hard parts such as shells. Asks pupils why this is significant for geologists.<br><br>Present diagrams showing arrangement of the continents in the Paleozoic. Use atlases to compare the position of continents in the Paleozoic with their current locations.<br><br>Look at examples of the collisions of the continents e.g. South America and Africa colliding with North America to form the Appalachians. Formation of the Caledonian, Arcadian, Hercynian and Ural orogenies.<br><br>Use atlas to locate some of the mountain ranges that were formed in this period. | Pupils could be asked to put the appearance of different organisms in chronological order or state the geological time when they occurred.<br><br>Descriptive writing activity - travelling back in time (see above). **LL**<br><br>As an alternative to the literacy activity above, students could imagine that time travel was possible in some future age. Ask them to design a travel brochure advertising a trip to the Paleozoic era. They should include relevant details regarding climate, flora, fauna, maps etc. **LL** | Students should be able to situate the Paleozoic Era on the geological timescale and know the different time periods into which it can be divided<br><br>Understand the main geological, geographic and biological characteristics of the Paleozoic Era including: the major tectonic plate movements that took place in the Paleozoic and the resulting mountain ranges that were formed and the main zone fossils of the Paleozoic including the trilobites, graptolites, brachiopods, goniatites and echinoderms. | Internet photos of the Paleozoic Era can be found at University of California Museum of Palaeontology http://www.ucmp.berkeley.edu/paleozoic/paleozoic.html<br><br>Global History Webpage shows plate tectonic reconstructions for all of the time periods in the Paleozoic http://jan.ucc.nau.edu/~rcb7/global_history.htm<br><br>The University of Texas has a similar site at http://www.scotese.com/earth.htm<br><br>Diagrams showing arrangement of continents in Paleozoic can be found in Essentials of Geology book by FK Lutgens & EJ Tarbuck, Chapter 19, Earth History Section on Paleozoic History.<br><br>School atlases. |

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| Core | <u>The explosion of life</u><br>Explain that life in early Paleozoic was restricted to the seas. Vertebrates had not yet evolved. Show more pictures of fossils from this Era (trilobites, brachiopods and cephalopods). Recap on work on zone fossils giving examples from the Paleozoic.<br><br>Use chapter 19 of Essential Geology to compile a chart of the development of plants and animals in the Paleozoic Era. Pupils have to match a key biological event with a particular time period. This chart could include details such as: the period when the trilobites were dominant, the first fish, the first land plants, the first insect fossils, amphibians become abundant, large coal swamps, the first reptiles, mass extinction etc. The students could produce posters of their charts.<br><br>Take an internet tour of geologic time at the University of California Museum of Palaeontology, focusing on the Paleozoic Era.<br><br>To finish this section pupils could read and write about some of the theories of the mass extinction at the end of the Permian. | Assess Paleozoic charts.<br><br>Essay on mass extinctions. **LL** | Explosion of life that took place in the Paleozoic and the geologic record which details among other things:<br><br>The first fish in the Ordovician.<br><br>The first vascular land plants in the Silurian.<br><br>The first insect fossils in the Devonian.<br><br>The amphibians appear in the fossil record in the Devonian.<br><br>The large coal swamps of the Carboniferous Period.<br><br>The earliest fossil record of the reptiles is from the Mississippian.<br><br>Extinction of many animals in the Permian. | University of California Museum of Palaeontology Tour of Geologic Time can be found at http://www.ucmp.berkeley.edu/exhibits/geologictime.php<br><br>Essential Geology FK Lutgens & EJ Tarbuck Chapter 19 Earth History: a Brief summary.<br><br>University of California Museum of Palaeontology Tour of Geologic Time can be found at http://www.ucmp.berkeley.edu/exhibits/geologictime.php<br><br>The great Paleozoic Extinction. Box 19.1 from Essentials of Geology book by FK Lutgens & EJ Tarbuck, Chapter 19, Earth History: A Brief Summary.<br><br>What Causes Mass Extinctions pages 42-45 of “From the Beginning” Natural History Museum book. |

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| Core | 8 The Mesozoic<br>As above use the geological column to question pupils about the Mesozoic Era. When did it begin? When did it end? What three periods make up the Mesozoic? What do you know about this era etc?<br><br>Use palaeographic map of Mesozoic period to show the break up of Pangaea.<br><br>Pupils could record these changes in their books matching these global events with their relevant time period e.g. during late Triassic North America began separating from Africa. This was followed by the rifting of North and South America. During late Triassic and Jurassic periods Antarctica and Australia which were joined, began separating from South America and Africa, and India began rifting from Gondwanaland. South America and Africa began separating during the Jurassic and Europe and Africa began converging at this time. During the Cenozoic Greenland separated from Europe and North America<br><br>Explain how the break up of Pangaea influenced global climatic and atmospheric circulation patterns and the effect that this had on evolution of living beings. | Descriptive writing activity on the Mesozoic Era - travelling back in time (see above). **LL**<br><br>Concept Quiz 4 from Essentials of Geology Website.<br><br>Provide various palaeographic maps showing the different stages of tectonic plate movements in the Mesozoic. Students discuss and arrange maps in the correct sequence and present their conclusions to the class. | Students should understand the main geological, geographic and biological characteristics of the Mesozoic Era including:<br><br>The major tectonic plate movements that took place in the Paleozoic and the resulting mountain ranges that were formed.<br><br>The proximity of the continents and generally mild climates allowed many plants & animals to spread over extensive geographic areas. | Global History Webpage shows plate tectonic reconstructions for all of the time periods in the Mesozoic http://jan.ucc.nau.edu/~rcb7/global_history.htm<br><br>The Paleomap Project at the University of Texas has a similar site at http://www.scotese.com/earth.htm<br><br>Internet quizzes on Chapter 19 of Essential Geology http://wps.prenhall.com/esm_lutgens_essentials_9 |

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| Core | Using maps look at some of the mountain ranges that were formed in this era with the collisions of the continents-the Alps, Pyrenees, Apennines and Himalayas.<br><br>Read Science 4 Santillana book to find out about Mesozoic flora and fauna or show students pictures of gymnosperms which are extinct now with the exception of a few species like the cycads.<br><br>Explain how the angiosperms appeared in the Cretaceous and began to predominate.<br><br>Show photographs of belemnites and the ammonites which are characteristic of the Mesozoic period. Ask students if they can remember the name we give to such fossils (zone fossils).<br><br>Show small section of Earth story video on ammonites.<br><br>Look at other examples of fossils of reptiles. The fossils found from this period include crocodiles, lizards, types of turtles and two types of sea reptiles plesiosaurus and ichthyosaurs. Show students pictures of pterosaurs, the flying predatory reptile. | | Towards end of Mesozoic the first angiosperms developed, plants with their seeds protected in a fruit, which permitted massive dispersion.<br><br>Two of the most characteristic fossils of this period are the belemnites and the ammonites.<br><br>During Jurassic, crocodiles became the dominant freshwater predators. Turtles and lizards were present during most of the Mesozoic. By the Cretaceous, snakes had evolved from lizards.<br><br>The transition from reptiles to mammals is well supported by fossil evidence. | Article including Picture of cycads: http://www.ucmp.berkeley.edu/seedplants/cycadophyta/cycads.html<br><br>Science 4 Biology & Geology Santillana Chapter 3 History of the Earth and Life.<br><br>Earth story DVD section on ammonites. |

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| Core | Pupils could then look at pictures of a variety of dinosaurs that would have existed during this era.<br><br>Show pupils image of archaeopteryx, the oldest known bird.<br><br>Explain to pupils that mammals evolved in this era but all were small and their diversity was low.<br><br>To conclude explain that the Mesozoic finished off with a mass extinction some scientists claim that this was caused by a large meteorite but others believe it may have been caused by other factors.<br><br>Read “Demise of the Dinosaurs” from the Essentials of Geology Book and explain how this mass extinction may have given rise to the predominance of mammals who could control their body temperature.<br><br>Prepare a mind map or a chart of the Mesozoic to help you revise. | Written accounts of the various theories as to what happened to the dinosaurs. | Archaeopteryx, the oldest known bird has so many theropod characteristics palaeontologists believe the two are related.<br>Dinosaurs had evolved by late Triassic and became dominant land dwelling vertebrate animals. Although now extinct they were successful for 140 million years.<br><br>Know that birds evolved from dinosaurs.<br><br>Among the victims of the mass extinction were dinosaurs, flying reptiles, marine reptiles and several groups of marine invertebrates. | Article / image of archaeopteryx http://news.nationalgeographic.com/news/2005/12/1201_051201_archaeopteryx.html<br><br>Demise of the Dinosaurs -Essential Geology FK Lutgens & EJ Tarbuck Chapter 19 Earth History: a Brief summary.<br><br>DVD Earth Story section on mass extinction. |

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| Core | 9 The Cenozoic Era<br>Use the geological column as above to question pupils about Cenozoic Era. When did it begin? When did it end? What periods make up the Cenozoic? What period are we currently in? What distinguishes the Cenozoic from the previous era? Why do we know more about this era than other eras etc?<br><br>Explain how the Cenozoic is divided into Tertiary and Quaternary and the relative time spans of each.<br><br>Use palaeographic maps to explain that the rifting of Pangaea continued throughout the Cenozoic and that this accounts for the present day position of the continents and oceans.<br><br>Explain to students that this era is sometimes referred to as the post-dinosaur period, the time of the mammals.<br><br>Read Santillana book. Summarise or take notes on climate, flora and fauna during the Cenozoic. | Descriptive writing activity - travelling back in time (see above). **LL**<br><br>Concept Quiz 5 from Essentials of Geology Website. | Pupils should know the main geological, geographic and biological characteristics of the Cenozoic Era.<br><br>Place the Cenozoic in the geological column. Know the different periods that make up the Cenozoic.<br><br>Tectonic activity continued from Mesozoic into the Cenozoic forming the Alps (convergence of African and Eurasian plates).<br><br>Rockies formed in North America.<br><br>Australia separated from Antarctica.<br><br>Africa and Arabia start to split. | Paleomap project has images of palaeographic maps for all of the periods in the Cenozoic http://www.scotese.com/<br><br>Internet quizzes on Chapter 19 of Essential Geology, Concept Quiz 5 http://wps.prenhall.com/esm_lutgens_essentials_9<br><br>Santillana book 4, Science, Biology & Geology Chapter 3.5 The Cenozoic Era. |

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| Core | Take internet tour of geologic time focusing on Cenozoic Era at University of California Museum of Palaeontology.<br><br>Look at the three major groups of living mammals in Hall of Mammals.<br><br>Discuss primate and human evolution. The more capable pupils could read Historical Geology Chapter 19 and try some of the questions at the end of the chapter.<br><br>Try internet activities on webpage of Essential Geology chapter 19.<br><br>Research BBC internet site "Science & Nature Prehistoric Life Human Beginnings. Contains story of Lucy and Caveman Facts. | Questions at the end of chapter 19 of Essentials of Geology book. | Mammals replaced reptiles as the dominant land animals.<br><br>Angiosperms continued to replace gymnosperms to become the dominant land plants.<br><br>To be able to place the appearance of the human species correctly in the geological column. | University of California Museum of Palaeontology Tour of Geologic Time can be found at http://www.ucmp.berkeley.edu/exhibits/geologictime.php<br><br>Hall of Mammals http://www.ucmp.berkeley.edu/mammal/mammal.htm<br><br>Historical Geology book by R Wicander & JS Monroe. Chapter 19 "Primate & Human Evolution.<br><br>Internet quiz on Chapter 19 of Essential Geology http://wps.prenhall.com/esm_lutgens_essentials_9<br><br>BBC Human Beginnings Site http://www.bbc.co.uk/sn/prehistoric_life/human/ |
| Extension | Field work. Take students to a suitable local outcrop to do a reconstruction of the history of a stratigraphic column for a particular time period. | | Do a basic reconstruction of history of your local area through a simple stratigraphic column. | |

**Topic: Plate Tectonics and their Effects**

**Assumed knowledge from previous years:**

The formation of Sedimentary rocks by processes including deposition of rock fragments.
The evidence gained from sedimentary layers, and from fossils, which has led to changes in ideas about the development of the Earth.
The formation of Metamorphic rocks by the action of heat and pressure on existing rocks.
How rock-forming processes are linked by the rock cycle.
The interactions within and between the physical processes which cause earthquakes and volcanoes and how people respond to them.
How these interactions create geographical patterns of tectonic activity and help change places and environments in 'active zones'.

**Content:**

1. The origin and formation of different types of mountain chains with some historical interpretations.
2. The rock cycle.
3. Evidence of continental drift and the formation of ocean ridges and the phenomenon of sea floor spreading.
4. The distribution of volcanoes and earthquakes.
5. Interpretation of the dynamic model of the internal structure of the Earth.
6. Plate tectonics, a revolution in Earth Sciences. Using plate tectonics to interpret landforms and geological events.
7. Assessing the consequences of a dynamic planetary interior on the Earth’s surface.

| h | Lesson outline | Assessment activities | Lesson outcomes | Resources |
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| Core Revision | A rock cycle practical circus: Pairs of students move around the 3 rock practical stations that are set up around the classroom.<br><br>Practical activity 1: Making a sedimentary rock by the process of compaction and cementation of sediments. Using different amounts of sand, clay and plaster of Paris.<br><br>Practical activity 2: Observing the formation of crystals in hot and cold environments. Identification of igneous rocks using crystal size.<br><br>Practical activity 3: Examine samples of metamorphic rocks and compare them with the sedimentary rock from which they are formed. (Characteristics compared include: crystal alignment, visible grains, hardness of rock, distortion of fossils and alignment of crystals). | To construct a flow diagram showing the rock cycle. Linking all rocks and their formation using given information and results form practical activities. | The rock cycle. Explain the sequence of rock formation. How sedimentary rocks may show evidence to indicate the conditions under which the sediments were deposited.<br>The formation of igneous rocks from lava flows and intrusions.<br>The formation of metamorphic rocks by high temperatures and pressures. | http://www.mineraltown.com/infocoleccionar/How_rocks_minerals_are_formed.htm<br>http://www.cet.edu/ete/modules/msese/earthsysflr/rock.html<br>http://www.minsocam.org/MSA/K12/rkcycle/intrusives.html<br>http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page02.cfm<br>Practical 1: Open ended plastic syringe lined with petroleum jelly, sand, clay, plaster of Paris and water.<br>Practical 2: Hot and cold glass microscopic slides, melted salol solution. Hand lens to observe size of crystals formed.<br>Rock samples: Obsidian (glass like, very fast cooling, surface of earth. Pumice (gas bubbles present, fast cooling, surface of earth. Basalt (small crystals, moderate cooling, near surface). Granite (large crystals, slow cooling, in depths of earth).<br>Practical 3: Rock sample: Limestone, chalk and marble. Sandstone and Quartzite. Shale and Slate. |

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| Extension | Write children's stories to explain how their chosen rock has been formed. Create rock grain characters; describe their lives so far with feelings of their experiences. | **LL**<br>The rock story. Assess the scientific accuracy, imagination and creativity. | | Essentials of Geology:<br>Pg. 16-17, figure 1.11 : The rock cycle,<br>Pg. 52-58: Naming igneous rocks,<br>Pg. 115-123: Types of sedimentary,<br>Pg. 145-147: Common metamorphic rocks.<br>Understanding Geology<br>Pg. 28, figure 4.2: The Rock cycle. |
| Core | Demonstrate the earth's internal structure. Set up a 500$cm^3$ beaker, with a depth of 1cm of wax at the bottom. 1$cm^3$ of sand on top of the wax and the beaker then filled with very cold water. Apply a strong Bunsen burner flame to the base of the beaker.<br>Students to relate the layers in the demonstration to the structures of the earth. The sand and water representing the crust and the mantle represented by the wax which is heated from a central point.<br>Create a display for the classroom showing the depths and boundaries of each different layer of the earth. The display to be annotated with the different temperatures and contents of each layer. | **GL**<br>Evaluate which structures of the model are not consistent with the natural world. | Know that the earth has a layered structure comprising of an atmosphere, a crust, a mantle and a core<br>Understand the nuclear processes that maintain the high temperatures within the core and the mantle. | AQA GCSE Foundation pg. 142, figure 8.3: The layers of the Earth.<br><br>Science plus Bk. 2, pg.40: What is the Earth made from?<br><br>Essentials of Geology, pg. 11:The solid earth.<br><br>Living Rock DVD, chapter 2: Continental crust.<br><br>Safety with demonstration: Equipment to be heated behind a glass safety screen.<br><br>Creating the display: 10km=1cm.<br>Crust to centre of earth=6m<br>Crust=2cm<br>Mantle=2.7m. |

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| Core | Construct the different continents out of cardboard. (Students are supplied with enlarged pictures of the continents to ensure the same scale is used).<br>Can the students put the continents together creating Pangea?<br>Students to label the main tectonic plates on a blank map of the world.<br>In their group's students are to hypothesise how the tectonic plates move and therefore think about how the continents separated, how can they physically move creating the earth as it is today? | **LL, HL**<br>Written hypothesis explaining the movement of continents using illustrated diagrams where needed to help explain theory.<br>Assessment can be based on imaginative hypothesis if scientifically correct but not in agreement with Wegener's theory. | Appreciate that Wegener's theory of continental drift became accepted during the 1950s and 1960s.<br>Know that the earth's crust and upper parts of the mantle are cracked into a number of very large tectonic plates. | Essentials of Geology<br>Pg. 13 & 14 Plate boundaries.<br>Pg. 315: Wegener theory of continental drift.<br>Pg. 319, figure 16.8 mosaic plates of earth's outer shell.<br><br>Understanding Geology, Chapter 13:Plate tectonics.<br><br>AQA GCSE Foundation, pg. 147, figure 8.9: The main tectonic plates and their direction of movement.<br><br>Separate continent diagrams: www.sd5.k12.mt.us/glaciereft/studentsheet.htm<br><br>Diagram of tectonic plates: http://www.geography.learnontheinternet.co.uk/topics/structureofearth.html#plateb<br><br>Movement of the tectonic plates from 245 million years ago: http://emvc.geol.ucsb.edu/animations/flash/pangea.swf<br><br>www.geology.com/pangea.htm |

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| Core | Hydrogen balloons to be hanging form the ceiling as the students arrive. Encourage a question/answer session on why the balloons rise? Introduce the idea of density and the fact that hydrogen is less dense than air and therefore rises.<br>Demo of convection currents: Heat up a crystal of potassium permanganate positioned carefully at the bottom of a $dm^3$ beaker. Introduce the theory behind convection currents in the astheriosphere and deeper parts of the mantle.<br>Teacher demonstration using the cardboard cut out of the continents from the previous lesson to demonstrate the movement continents giving the correct hypothesis of continent drift. | Written explanations of continental drift and plate tectonics. | Know that convection currents with the earth's mantle cause the plates to move at relative speeds of a couple of cm/year. | Understanding Geology, pg. 148, figure 13.17b :Convection cells in the earth's mantle.<br>Pg. 148 Explanation of plate movement.<br><br>Essential Geology<br>Pg. 315 Wegener theory of continental drift.<br>Pg. 319 Comparing Wegener's proposal and modern day views.<br><br>Living Rock DVD, chapter 5: Plate tectonics.<br><br>Hydrogen balloons.<br><br>Beaker ($1dm^3$), potassium permanganate crystals.<br><br>Separate continent diagrams: www.sd5.k12.mt.us/glaciereft/studentsheet.htm |

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| Core | Recap longitude and latitude. Demonstrate locating a volcano/earthquake onto an outline map; discuss symbols to be used. Using a list of recent volcanoes/earthquakes (longitude and latitude information included) the students are to locate these on a world map.<br>Students to describe the pattern they see and comment on the relationship between the two.<br>Students to draw on and label the main tectonic plates and then examine the relationship between volcanoes/earthquakes and plate margins. | | **GL**<br>Describe the general distribution of fold mountains, volcanoes and earthquakes and explain how this distribution is related to movements at plate boundaries. | Understanding Geology, pg. 31: An introduction to volcanoes.<br><br>Living Rock DVD, chapter 8 & 14, Volcanic activity and Earthquakes.<br><br>Diagram of tectonic plates: http://www.geography.learnontheinternet.co.uk/topics/structureofearth.html#plateb<br><br>Earthquakes world wide in the last 30 days http://www.iris.edu/seismon/last30days.phtml<br><br>Atlas.<br>World map.<br>List of recent volcanoes/earthquakes. |

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| Core | Recap and introduce the concept of plate tectonics, their movement and types of margins ( constructive, destructive and conservative).<br>Students to get into groups of four and assigned a number 1-4.<br>All number ones are to join a group and research destructive plate margins, number 2 conservative margins, number 3 constructive margins and number 4 collision margins. The students return to their groups and using plasticene as an aid they take it in turns to describe and explain their different plate margin.<br>The students return to their previous groups and prepare a power point presentation on the types of geological structure formed at their plate boundaries. The presentation to include; the different types of mountain formed, whether there is ocean spreading or formation of mountain ridges, effects of earth's forces and world wide examples. | **GL**<br>Illustrated notes on the movement of the tectonic plates the geological structures formed.<br><br>ICT link: power point presentation. | To understand the earth in terms of tectonic plates.<br>To explain resultant landforms: earthquakes and volcanoes.<br>How Wegner's theory accounted for mountain building and formation of mountain chains: types and their associated geological processes. | AQA GCSE Foundation pg. 147,148 & 149, types of plate margins.<br>Understanding Geology,<br>pg. 140-146: The types of plate margins.<br>pg. 149 Summary table showing types of plate margins.<br>Essential geology<br>Pg. 322: Plate boundaries and types.<br>Pg. 356-368 Mountain types and their formation.<br><br>Atlas.<br>World map.<br>Information sheets on different plate margins.<br>Plasticene<br>Diagrams and information on types of plates:<br>http://www.earthscienceeducation.com/resources/Thru_the_window_KS4.doc<br><br>*http://www.cet.edu/ete/modules/msese/earthsysflr/plates2.html*<br><br>Types of mountains:<br>www.woodlands-junior.kent.sch.wk/Homework/mountains/types.htm#types<br><br>http://www.mountain.org/education/subexplore/explore02.cfm |

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| Extension | The virtual volcano: The virtual field trip. Produce a visitors leaflet on a visit to the chosen volcano. Leaflet to include maps and possible walking routes, flora and fauna, hazards spots and highlights of the trip. | **LL, GL**<br>Visitors leaflet. | Assess the consequences of the earth's dynamic interior with regards to the formation and eruption of a volcano.<br>Understand how volcanic areas can best be put to economic use. | The virtual volcano:<br>www.swisseduc.ch<br>www.field-trips.org/tours/sci/volcano/-tourlaunch1.htm |

## Bands of attainment

The bands of attainment described below are for ESO 4.
Band 1 30% pupils will not have made so much progress and will have reached or may be struggling at this level.
Band 2 60% pupils will have reached this level.
Band 3 10 % pupils will have progressed further and will have reached this level.

**Band 1 :**

Students recall a limited range of information. They use and apply knowledge and understanding in some specific everyday contexts and are able to make some use of scientific and technical vocabulary and make simple generalisations from information. They relate scientific explanations to some experimental evidence and describe simple examples of benefits and drawbacks of scientific development. They devise fair tests in contexts which involve only a few factors, for example, in the simulation experiment on Darwin's theory of evolution as outlined on page 44. Pupils in this band would appreciate the necessity of carrying out the experiment in controlled conditions e.g. size of square, number/ colour of pegs, amount of time given to search etc. They use simple apparatus to make measurements appropriate to the task and record observations and measurements in tables and graphs. They can, with some guidance, obtain information from simple tables, charts and graphs and identify simple patterns in information and observations. They offer explanations consistent with the evidence obtained.

**Band 2 :**

Students recall a range of scientific information from all areas. They use and apply scientific knowledge and understanding in some general contexts. They describe links between related phenomena in different contexts, use diagrams, charts and graphs to support arguments, use appropriate scientific and technical vocabulary in a range of contexts. They describe how evidence is used to test predictions made from scientific theories, and how different people may have different views on some aspects of science. They use scientific knowledge and understanding to identify an approach to a question. For example, in the simulation experiment on Darwin's theory of evolution, they use a range of apparatus to make careful and precise measurements and systematic observations and recognise when it is necessary to repeat measurements and observations. They present data systematically, in graphs where appropriate. They identify and explain patterns within data and draw conclusions consistent with the evidence. They explain these conclusions using scientific knowledge and understanding and evaluate how strongly their evidence supports the conclusions.

**Band 3 :**

Students recall a wide range of knowledge from all areas. They use detailed scientific knowledge and understanding in a range of applications relating to scientific systems or phenomena. For example, they can plan, carry out and evaluate a simulation experiment to illustrate Darwin's theory of natural selection as outlined on page 44. They draw together and communicate knowledge from more than one area, use routinely scientific or mathematical conventions in support of arguments, use a wide range of scientific and technical vocabulary throughout their work. They explain how scientific theories can be changed by new evidence and identify some areas of uncertainty in science. They use scientific knowledge and understanding to select an appropriate strategy for a task, identifying the key factors to be considered. They make systematic observations in qualitative work and decide which observations are relevant to the task in hand. When making measurements they decide the level of precision needed and use a range of apparatus with precision and skill to make appropriately precise measurements. They select a method of presenting data appropriate to the task; they use information from a range of sources where it is appropriate to do so. They identify and explain anomalous observations and measurements and the salient features of graphs. They use scientific knowledge and understanding to identify and explain patterns and draw conclusions from the evidence by combining data of more than one kind or from more than one source. They identify shortcomings in the evidence, use scientific knowledge and understanding to draw conclusions from their evidence and suggest improvements to the methods that would enable them to collect more reliable evidence.

## Development of Scientific ways of thinking

It is possible to give an outline of how we expect the pupils to develop scientifically throughout the course, although they will not all develop at the same rate. It is important for teachers to be aware that there will be a mixture of levels in any class and to try to ensure that their questions and the work set is differentiated to encompass this variety:

**Lower levels of attainment**
Pupils will be able to recall information, use some basic scientific vocabulary, describe what happens and answer basic questions about why something happened. For example, they will know that variation is caused by both genetic and environmental factors. They will know that some characteristics are passed on from parents to their offspring and that this is called 'inheritance'. They will be able to recall Mendel's experiments on inheritance using pea plants and will understand that crossing purple and white flowering pea plants will produce either purple or white flowering offspring but never pink.

**Middle levels of attainment**
Pupils will begin to use abstract ideas and models in their answers. They will be able to explain their observations: This happens because... They will have a more detailed knowledge of cell structure than the lower band. They will understand that the information that controls inherited characteristics is carried by genes which are passed on in the gametes and understand that a gene is a section of a chromosome that is found in the nucleus of a cell. They will be able to use a Punnet square to demonstrate an understanding of the cross breeding process and calculate the percentage of offspring with a specific genotype.

**Higher levels of attainment**
Pupils at this level will be able to apply abstract ideas, models and theories to explain phenomena. They will be able to find patterns in their observations and begin to explain their conclusions in a logical and reasoned way. Pupils at this level should have a detailed knowledge of cell structure. They will be able to predict the percentage of offspring with a specific genotype in the cross breeding process and verify their predictions using Punnet squares. They should understand the causes of variation and mutation and be able to put forward reasoned arguments, based on sound scientific knowledge, regarding economic, social and ethical issues related to genetics (e.g. designer babies, GM foods, animal cloning etc).

## Useful Websites and Internet Resources

**General Reference:**

www.scienceacross.org

http://www.standards.dfes.gov.uk/schemes2/secondary_science/?view=get
Part of the official government site for the National Curriculum, this site includes schemes of work and resource links for all the topics at all levels of secondary science. Very useful references guide.

http://www.qca.org.uk/12265.html
The official site of the QCA (Qualifications and Curriculum Authority), with information about science teaching at Key Stage 4.

http://www.worldofteaching.com/biologypowerpoints.html
Biology downloads for science teachers.

**Geology:**

Plate Tectonics and their effects:

http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page02.cfm
Interactive rock cycle.

http://www.cet.edu/ete/modules/msese/earthsysflr/rock.html
Illustrated rock cycle.

www.sd5.k12.mt.us/glaciereft/studentsheet.htm
Student diagrams of the separate continents.

http://emvc.geol.ucsb.edu/animations/flash/pangea.swf
movement of the tectonic plates 245 million years ago.

http://www.geography.learnontheinternet.co.uk/topics/structureofearth.html#plateb
Diagram of the tectonic plates.

www.geology.com/pangea.htm
Pangea continent maps.

http://www.iris.edu/seismon/last30days.phtml
Earthquakes world-wide in the last 30 days, longitude and latitude positions quoted.

http://www.seed.slb.com/en/scictr/watch/living_planet/glossary.htm
Glossary and references of all key geological words with diagrams, photos and animations.

**Module 2: The History of the Earth:**

http://geology.about.com/
An extensive geology site useful for both pupils and teachers.

http://wow.osu.edu/experiments/geology/mdfossils.html
Simple web site explaining how students can make their own fossils and learn about where and when certain fossilised animals lived in the past.

http://www.ucmp.berkeley.edu/
Detailed web site of University of California Museum of Palaeontology. Contains thousands of pages on history of life on Earth. Includes tour of geologic time.

http://wps.prenhall.com/esm_lutgens_essentials_8/0,6602,236553-,00.htm
Very useful site to accompany the book "Essentials of Geology" by Frederick K Lutgens & Edward J Tarbuck. Chapters 18 and 19, containing information on Geological Time and Earth History are particularly suitable for this module.

http://pubs.usgs.gov/gip/fossils/intro.html
US Geological Survey site containing child friendly information on relative / absolute dating, fossils, geologic time scales.

http://paleobiology.si.edu/geotime/main/index.html
Smithsonian National Museum of Natural History. Extensive web site with useful interactive geological timeline.

http://www.rom.on.ca/schools/fossils/index.php
Royal Ontario Museum WebPages. Contains activities for students on fossils.

http://www.chemsoc.org/networks/learnnet/jesei/index2.htm
Joint Earth Science Education Initiative contains some useful resources including activities on some of the early theories of the age of the Earth.

http://www.bgs.ac.uk/education/home.html
British Geological Survey Web Site. Comprehensive web site with links to many educational activities.

http://www.rockwatch.org.uk/index.htm
Geology club for young students.

http://www.esta-uk.org/main.html
Earth Science Teachers Association. A web site aimed at supporting both specialist and non- specialist teachers of Earth Science.

## Biology:

### -Heredity and Transmission

Chromosome numbers:
http://www.vivo.colostate.edu/hbooks/genetics/medgen/basics/minmax_chromos.html
http://www.cellsalive.com/cells/3dcell.htm

Chromosome images:
www.genome.gov

Mutations:
http://en.wikipedia.org/wiki/Peppered_moth_evolution
peppered moth wikipedia
http://www.talkorigins.org/faqs/wells/images/grantfile.jpg
map of distribution of peppered moth
http://www.microbeworld.org/
photo electronmicrographs of cellular organelles
http://www.denniskunkel.com/DK/DK/Medical/

DNA:
http://www.pbs.org/wnet/dna/
www.miniscience.com/projects

http://www.thetech.org/genetics/
extracting DNA.

Mendel and genes:
http://www.fieldmuseum.org/mendel/
http://biology.about.com/od/mendeliangenetics/Mendelian_Genetics.htm
http://www.bbc.co.uk/schools/gcsebitesize/biology/variationandinheritance/

Antibiotic-resistant bacteria mutations
http://news.independent.co.uk/uk/health_medical/article2083867.ece
http://archive.malverngazette.co.uk/2005/8/27/372699.html
http://news.scotsman.com/scotland.cfm?id=11192007

Inheritable conditions
http://www.nowtryus.com/article:Sickle-cell_anemia
Detailed account of Sickle cell anaemia.

**The Origin and Evolution of Living Organisms:**

http://www.pbs.org/wgbh/evolution/educators/teachstuds/svideos.html
Useful video clips giving information on a variety of evolution topics.

http://upload.wikimedia.org/wikipedia/en/thumb/d/dd/Horseevolution.png/275px-Horseevolution.png
Images of the evolution of the horse.

http://www.scienceagainstevolution.org/v8i1f.htm
Images of the evolution of man.

www.guardian.co.uk/international/story/0,,1337643,00.html
Newspaper article on the discovery of the Flores man.

**Dynamics of Ecosystems**

http://www.s-cool.co.uk/default.asp
Questions and summaries for GCSE revision on environment and environmental problems.

http://www.mrothery.co.uk
Ecology is module 5 this web site includes notes, summaries and hand-outs.

http://www.biologycorner.com/worksheets.php
links to interesting ecology pages.

http://www.bbc.co.uk/schools/gcsebitesize/biology/livingthingsenvironment/
revisions notes and tests on habitats and populations.

http://regentsprep.org/regents/biology/units/ecology/index.cfm
glossary and references of key words with diagrams, photos and resources.