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A LEVEL
Transition Guide

GEOLOGY

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For first teaching in 2017

KS4 Science – KS5 Geology

Version 1

www.ocr.org.uk/alevelgeology

A LEVEL *GEOLOGY*

Key Stage 4 to 5 Transition Guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 4 which will help prepare students for progression to Key Stage 5;
- Common student misconceptions in this topic.

Transition Guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 4 and 5 and are designed to be of use to teachers of both key stages. Central to the Transition Guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 4 and assess their 'readiness for progression' to Key Stage 5 content on this topic. This Checkpoint task can be used as a summative assessment at the end of Key Stage 4 teaching of the topic or by Key Stage 5 teachers to establish their students' conceptual starting point.

Key Stage 4 to 5 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 4 Content – Biology

GCSE (9–1) content (Statements from the Biology single Science GCSE and the Combined Science GCSE):

- describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of new species
- explain how evolution occurs through natural selection of variants that give rise to phenotypes best suited to their environment
- describe the evidence for evolution, including fossils
- describe the impact of developments in biology on classification systems

Key Stage 5 Content – Geology

A Level content

- 2.2.1(b) the nature and the reliability of the fossil record and the morphological definition of species
- 2.2.1(c) the use and interpretation of fossils as palaeoenvironmental indicators: body fossils to provide information on the behaviour of the fossilised organism and the palaeoenvironment.
- 2.2.2(b) the geochronological division of the geological column for the Phanerozoic into eras and systems using a biostratigraphic relative time sequence
- 4.2.1(d) biostratigraphic correlation using first appearance of macro fossils, stratigraphic range, extinction and fossil assemblages
- 7.1.2(a) how the evolution of life on Earth, displayed in the marine fossil record, is used as evidence to investigate long term gradual change
- 7.1.2(b) how the evolution of life on Earth, displayed in the terrestrial fossil record, is used as evidence to investigate long term gradual change

Key Stage 4 Content – Chemistry

GCSE (9–1) content (Statements from the Chemistry single Science GCSE and the Combined Science GCSE):

- recall and explain the main features of the particle model in terms of the states of matter and change of state, distinguishing between physical and chemical changes
- use data to predict states of substances under given conditions

Key Stage 4 Content – Physics

GCSE (9–1) content (Statements from the Physics single Science GCSE and the Combined Science GCSE):

- describe how, when substances melt, freeze, evaporate, condense or sublimate, mass is conserved, but that these physical changes differ from chemical changes because the material recovers its original properties if the change is reversed
- describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state
- explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relation between the temperature of a gas and its pressure at constant volume (qualitative only)

Key Stage 5 Content – Geology

A Level content

- 3.2.2(a) the generation of mafic magma by partial melting which results from upwelling of the mantle at divergent plate boundaries and intraplate hot spot settings
- 3.2.2(b) the generation of intermediate and silicic magmas at convergent plate boundaries where crustal material is carried downward resulting in partial melting
- 3.2.2(e) how changes in the properties of magma can affect buoyancy forces such that the magma can make its way to the surface producing a volcanic eruption; practical investigations to model the properties of magma and how changes to conditions can affect buoyancy forces
- 5.3.1(a) the substitution of elements for others in the crystal structure of minerals and as magma cools and crystallises (olivine and plagioclase feldspar as examples of solid solution series); the interpretation of continuous and discontinuous binary phase diagrams

Key Stage 4 Content – Physics

GCSE (9–1) content (Statements from the Physics single Science GCSE. The final bullet is also from the Combined Science GCSE):

- recall the main features of our solar system, including the similarities and distinctions between the planets, their moons, and artificial satellites
- recall that our sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the fusion energy
- describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), compare the ways in which they are used and distinguish between renewable and non-renewable sources

Key Stage 5 Content – Geology

A Level content

- 3.1.2(b) a qualitative explanation of the nebular hypothesis for the formation of the solar system and the Earth
- 3.1.2(c) the transfer of geothermal energy from: heat of formation by the Earth

Comment

Recent changes in the National Curriculum have significantly reduced the explicit Earth science content in KS4 sciences and transferred some topics to KS4 geography where they are taught as place based studies. This has the potential to confuse learners who may not identify how familiar GCSE scientific principles apply in geological contexts and could assume that they are required to apply a more descriptive geographical approach. Conversely teachers of A Level Geology who do not teach GCSE sciences may not be aware of the significant scientific knowledge of learners which is directly applicable to A Level Geology learning. By considering the themes and trends in these topics at KS4 sciences and KS5 geology it is possible to see differences within the content and application.

KS4 sciences learners can be prepared for progression to KS5 geology by making slight tweaks to the program of study and mentioning geological applications when these occur. Phase diagrams could be introduced earlier when carrying out work on changing state. At Key Stage 4 learners should become confident in using the periodic table as a resource and be fluent in using examples of elements and compounds. Rock forming minerals could be referred to when looking at the chemical formulae of compounds or the chemical behaviour of oxides or sulfides in KS4 sciences.

Evolution

At KS4 (Combined Sciences and Biology single Science GCSE (9-1)) learners consider the general mechanism when studying evolution by looking at the gradual change of species over time and the fact that selection is acting on variation within a species. Learners may consider that the fossil record gives some evidence for evolution and that comparison of older and younger species demonstrate an increase in complexity through time. Other evidence of evolution which learners may consider is that some species which are present today are not found in the fossil record while other species which are found as fossils are now extinct.

Studying evolution at KS5 geology requires learners to acquire a significant technical vocabulary and apply it to describe the unique sequence of evolutionary change to biostratigraphy including biostratigraphic division of time periods. When introducing the concept of a zone fossil, teachers should be aware that some learners can find it difficult to understand that only a few species are suitable as zone fossils; those which show a rapid evolution of morphological features.

The main challenges for learners are: relating to species which do not have present day equivalents, understanding the implications of the more complete marine record versus the patchy terrestrial record, and both recalling and understanding new terminology including that for time periods, fossil groups and morphology.

States of Substance

At KS4 sciences learners are able to describe states of matter and identify a state when given data on melting and boiling points. Learners are aware that different materials have different specific heat capacities (the energy required to increase the temperature of 1kg of substance by 1°C) and that specific latent heat of a substance is the energy required per kilogram to change its state without any change in temperature. At KS5 geology the focus is on partial melting and fractional crystallisation. Learners will need to apply their KS4 understanding of how pure substances melt or freeze at a fixed temperature to consider the behaviour of mixtures which melt or freeze over a range of temperatures. The specific settings where melting and crystallisation occurs within and at the margins of tectonic plates and the way crystals and melt (liquid rock) can evolve will also be new to learners. Phase diagrams can map the evolution of a melt or crystallisation of a magma; these will be unfamiliar to learners at KS4 so will need support and scaffolding when introduced.

Learners will find using phase diagrams quite different to the type of plotting and interpreting of graphs they have done at KS4. As an example, a H_2O + NaC*l* mixture phase diagram that can be used with KS4 learners could be used (Activity 1.1), and a linked resource which shows a phase diagram for water could then be provided to allow them to consider work done on physical properties. Other challenges may include visualising the process of partial melting under high pressures and how proportionately small amounts of melt can evolve and migrate.

Thermodynamics

At KS4 sciences learners will have studied the Big Bang as an unbelievably large explosion following which matter began to form, eventually cooling sufficiently to allow slow grouping together of matter under gravitational attraction to make the embryo of a star. Over time the temperature in the center of the star was high enough to allow nuclear fusion reactions to begin. At KS5 learners must

build on this background to understand how the planets of the solar system formed from a protoplanetary disc, how the Earth accreted and differentiated from this disc and how the transfer of energy within the Earth produces the geothermal gradient and the plate tectonic settings which result in the generation of magma.

Energy transfers are studied at several points in KS3 and KS4 sciences, these are opportunities to introduce the concept of the geothermal gradient as examples of processes within the Earth rather than limiting examples to those which occur on the Earth's surface and atmosphere or immediately familiar examples. Extending examples and contexts to geological processes helps learners at KS3 and KS4 to start thinking synoptically in their understanding of science and aids their understanding of how the rock cycle, volcanism and plate tectonics work.

Activities

Evidence for evolution (its all in the bones): Nuffield

Resources: http://www.nuffieldfoundation.org/science-society/activities-evolution

This sequence of activities progresses from describing mammalian bone structures, then linking these to adaptations of mammals and finishes with guiding learners through questions which connect observations to evolutionary theory.

Stages of natural selection (evolution cards): Nuffield

Resources: http://www.nuffieldfoundation.org/science-society/activities-evolution

This activity focuses on the mechanism which explains evolution; learners are provided with two examples, bacterial resistance and the peppered moth and must rearrange the cards to show the main events in the theory of evolution.

Interpreting observations (Darwin's finches): Nuffield

Resources: http://www.nuffieldfoundation.org/science-society/activities-evolution

Using some of the observations which Darwin made on his voyage to the Galapagos islands learners discuss reasons and interpretations for what was seen.

Changes of state: The Royal Institution

Resources: https://www.youtube.com/watch?v=PgI63_II-IA

Selection of demonstrations from the Royal institute Christmas lectures, entertaining delivery, range of phase changes covered.

The Big Bang: IOP

Resources: https://www.youtube.com/watch?v=jms_vklUeHA

The expanding universe, the Big Bang and dark matter clearly explained by a range of scientists.

Thermal properties of water experiments: RSC

Resources: http://www.rsc.org/learn-chemistry/resource/res00001782/the-thermal-properties-of-water

Two simple but effective demonstrations to show the thermal properties of water. Using a paper cup water as a conductor and convection currents are shown. The high specific heat capacity of water is shown by the balloon experiment.

Does salt make ice melt? Using a phase diagram to explain everyday phenomena

Resources: Learner Activity 1

Introduces the concept of phase diagrams for a binary system (using mixture of H_2O and $NaCl$ as an example). Does the salt melt the ice? How much salt do we need to clear the playground? Making ice cream with salt, what is ice cream (ice + syrup + butter fat)?

Introducing phase diagrams: Splung.com

Resources: http://www.splung.com/content/sid/6/page/phasesofmatter

Definitions of each state of matter, details of changing state, at the end of the page is a phase diagram for water which clearly introduces the new type of graphs to learners.

Changing state and the five states of matter: Live Science

Resources: http://www.livescience.com/46506-states-of-matter.html

A useful summary of states of matter linked to types of energy. Includes some stretch and challenge by considering plasma and Bose-Einstein condensates as less common states of matter.

Checkpoint task

The geological setting of the Checkpoint task is a cross section through an imaginary rock outcrop exposed in the side of a valley. The sequence includes igneous features and a sedimentary sequence. A number of fossils have been identified in the area. Firstly learners use the fossils present to discuss how fossils can be used in dating a sequence of rocks. The second part of the task involves linking the geothermal gradient to different plate tectonic settings. The final part of the task involves interpreting a phase diagram in terms of both crystallisation of a magma and formation of magma.

The Checkpoint task requires learners to apply their knowledge of each of these topics to unfamiliar settings, they must consider the incomplete nature of the fossil record and compare and contrast a fossil's suitability as a zone fossil. Learners must interpret a wide range of data, they must account for patterns they see and suggest why these patterns arise.

Using a phase diagram to consider both melting and crystallisation offers stretch and challenge to learners. At KS4 they learnt that at a change of state the temperature remained constant while bonds were being broken/formed. Using a phase diagram they are being asked to consider more complex systems where mixtures evolve.

Teacher Guidance:

The Checkpoint task is intended to be used with Year 11 or Year 12 sciences learners in the summer term to give them a flavour of geology. It serves to show them that they are not starting geology from scratch but already have relevant scientific knowledge and understanding which they can apply. While it will allow teachers of geology to assess learners' existing understanding it is not intended to be a test but is an exploration of existing knowledge and understanding in a new context.

It is assumed that learners will have had some exposure to phase diagrams and the "Does salt make ice melt?" insert link activity is provided as an analogous example of the behaviour of a binary mixture under different concentrations (many igneous rocks may be modelled as simple binary mixtures of two minerals). Alternatively learners could investigate: zone fossils (sometimes called index fossils), phase diagrams (i.e. H_2O + NaC*l*) and partial melting (the Geological Society's Plate Tectonics is an excellent resource - https://www.geolsoc.org.uk/Plate-Tectonics) through flipped learning prior to the lesson; they will need some guidance to research material at an appropriate level.

The resource sheet presents the geological section using the standard set of rock stipples (regular black and white patterns) and information for each fossil is summarised in the style of geology top trumps. Appropriate background is provided in the stem of each activity within the Checkpoint task and supplementary detail is given in the glossary. However, learners are not expected to have detailed knowledge of individual fossils or rocks (beyond the fact that some are sedimentary and other igneous).

Checkpoint Task:

www.ocr.org.uk/Images/345452-ks4-science-ks5-geology-checkpoint-task.doc

Activities

Magma formation and crystallisation:

http://webgeology.alfaweb.no/webgeology_files/english/magmatism.html

Very clear animation in the magma, lava and crystallisation and the magma formation section which contain just the right level of detail and explanation to be accessible to KS5 learners.

Biostratigraphy

http://webgeology.alfaweb.no/webgeology_files/english/geol_time_eng.html

In the fossils and depositional ages section is an animation to show how fossils can be used to date the rocks they are contained in, animation uses trilobites, brachiopods and corals.

Stratigraphy

http://basin.earth.ncu.edu.tw/download/courses/sequence_strat/4_biostratigraphy.pdf

Detailed account of biostratigraphy including numerous definitions, examples and case studies. Includes background to classification and average species length of time which is linked to suitability as a zone fossil.

The Earths energy sources: UCL

http://www.ucl.ac.uk/EarthSci/people/lidunka/GEOL2014/Geophysics8%20-%20Thermal%20evolution/Heat.htm

Begins with a straight forward explanation of energy sources on Earth, continues to compare primordial heat sources and radiogenic heat sources.

Primordial heat sources: University of Maryland

http://www.geol.umd.edu/~jmerck/geol212/lectures/10.html

Clear explanations of primordial heat sources and radiogenic heat sources supported by diagrams.

All the energy in the Universe is…: Ted ed

http://ed.ted.com/lessons/all-of-the-energy-in-the-universe-is-george-zaidan-and-charles-morton

Discusses the concept that the total energy in the Universe cannot change, a wide range of energy changes discussed in an accessible manner.

Partial melting coupled with plate tectonics: Earth learning idea

http://www.earthlearningidea.com/PDF/82_Partial_melting.pdf

This activity begins with a practical to model partial melting with a beaker containing gravel and wax, this demonstration then links to a variety of settings where partial melting produces rocks which are progressively richer in silica and depleted in Mg/Fe.

Activities

Evolution – it's a thing: Crash course

https://www.youtube.com/watch?v=P3GagfbA2vo

A detailed account of the theory of evolution, fossils, homologous structures, biogeography and observations.

A selection game: The Royal Institution

http://rigb.org/christmas-lectures/teaching-resources/2013-life-fantastic/natural-selection

Darwin introduces the game of natural selection through a projection. Children test their suitability as predators competing against each other for sweets. Summary and extension questions included.

Bear Island: OCR

http://www.ocr.org.uk/Images/163772-bear-island-the-jelly-bear-evolution-game.pdf

This activity was designed as an AS topic exploration pack but has proved to be quite adaptable and has been used by Biology teachers in a variety of ways. It can be used as a revision game with GCSE learners or as an A level Biology taster which can be adapted to allow learners to reflect on the nature of the fossil record.

This game helps learners to understand the impacts of evolutionary pressures. It can be extended by considering whether the different coloured bears would be classified by palaeontologists as different species and whether the behaviour of the bears would result in different trace fossils.

After playing the game learners should consider:

- Would the different coloured bears be classified by palaeontologists as different species? How might the physical adaptations of the different coloured bears be manifested in their fossilised remains?
- How would the behaviour of the bears result in different trace fossils produce by walking, feeding or denning activity?
- How would the preservation potential of the different coloured bears vary and would they be most likely to form life or death assemblages?

Resources, links and support

Science Spotlight – Our termly update Science Spotlight provides useful information and helps to support our science teaching community. Science Spotlight is designed to keep you up-to-date with science here at OCR, as well as to share information, news and resources. Each issue is packed full with a series of exciting articles across the whole range of our science qualifications: www.ocr.org.uk/qualifications/by-subject/science/science-spotlight/

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