The Bone Trail: contents
Emm Barnes, April 2006

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The meaning of fossils
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Geology debate sheet
Travelling with dinosaurs
Dinosaurs and art pack
Comparative anatomy sheet
Fossilisation sheet
Lyell sheet
Making sedimentary rock
Geological timeline
Edible geology
Final activity

Additional resources (available on loan)
Replica fossil iguanadon teeth
Large wall map of Smith's 1815 survey
Large wall map of contemporary geological survey
Wall map of solid geology in Manchester region

Resources required
Making sedimentary rock: Epsom salts
Geological timeline: approx 11 10m rolls of paper and pads of A4 graph paper
Edible geology: bread and sandwich fillings, chocolate, glace cherries, cereal and biscuits
Final activity: pliable modelling wire, chicken wire, newspaper, modelling roc, acrylic paint

The Bone Trail
Emm Barnes, Peter Fowler, & Alison Henning
March 2006

The Bone Trail

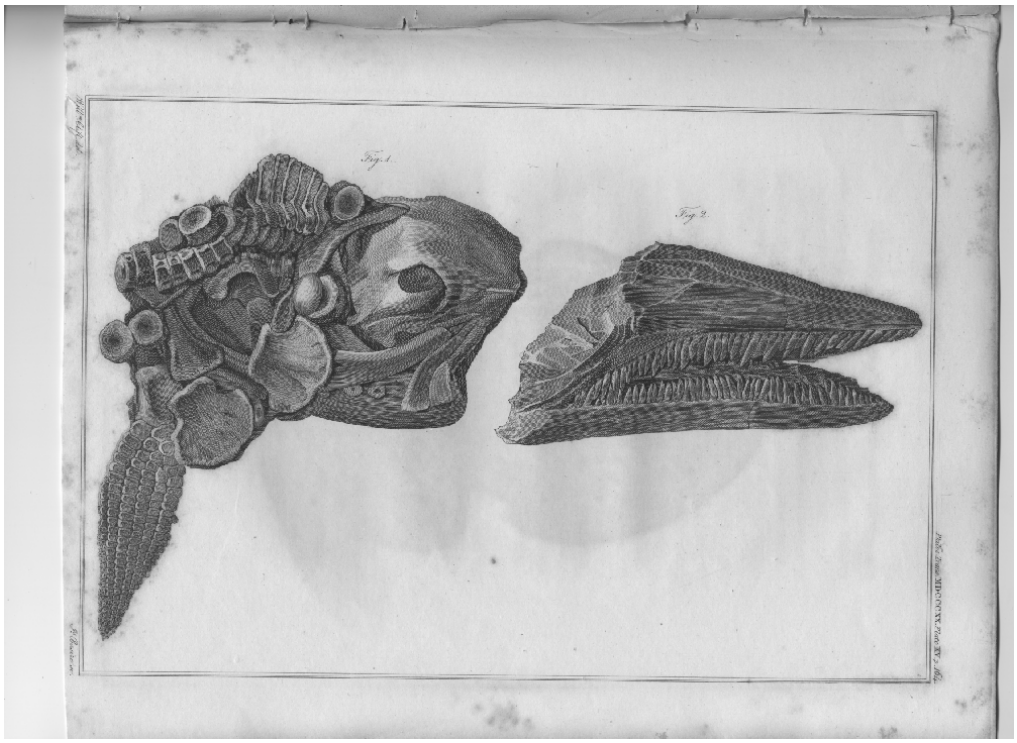


Illustration of “Proteosaurus” from a paper by Sir Everard Home
in “Philosophical Transactions,” 1820.
Picture courtesy of Professor Hugh Torrens.

A series of activities for Key Stage 3, History and Science.

With assistance from:
The Manchester Museum
Bolton Local Authority
Westhoughton High School
Hugh Torrens, Eric Robinson
Philip Manning

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The Bone Trail

A joint project of the British Society for the History of Science,
Secondary Strategy and Bolton Local Authority,
The Manchester Museum, and Westhoughton High School,
with assistance from Hugh Torrens, Eric Robinson, and Philip Manning

For Key Stage 3, History and Science

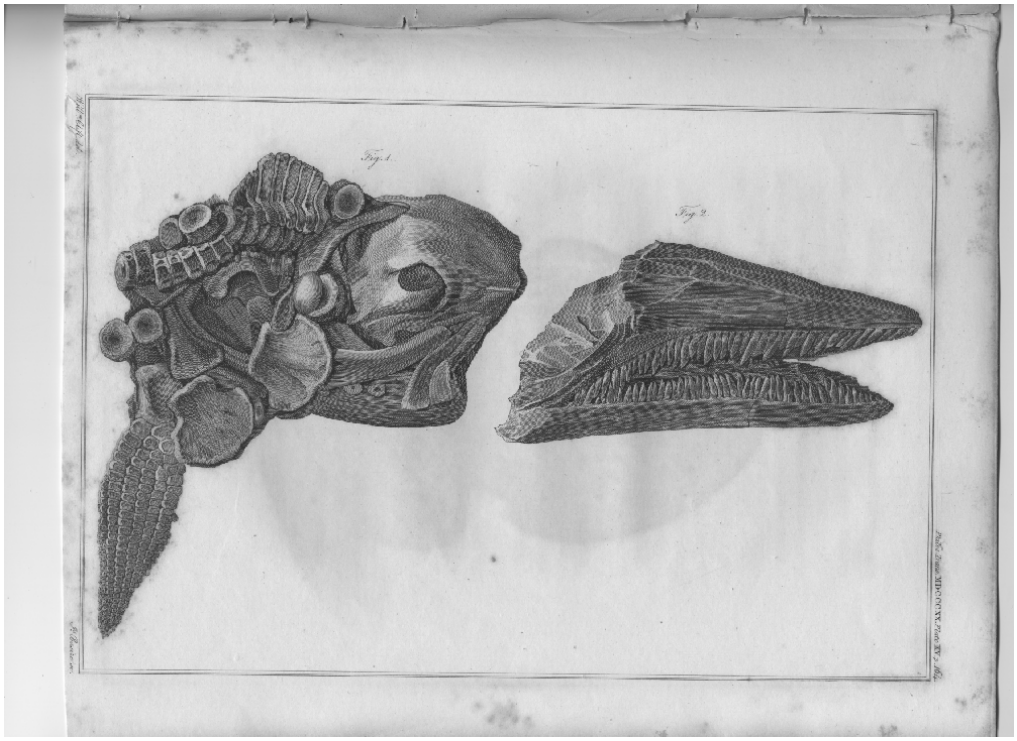


Illustration of “Proteosaurus” from a paper by Sir Everard Home
in “Philosophical Transactions,” 1820.
Picture courtesy of Professor Hugh Torrens.

Teachers guide to activities

There are 6 lessons, 3 history and 3 science. The pairs teach the same thinking skill in both history and science, and start from the same theme.

Each of the lessons could be delivered in 40 minutes with some homework, or more at more leisurely pace in 80 minutes. Alternatively, the activities could be mixed and matched for one or more interdisciplinary off-timetable days.

There is an optional introductory exercise which could be used in the first lesson or at start of an off-timetable day. The activities culminate with a visit to a museum with a collection of fossils and dinosaur reconstructions, and/or with a large-scale art project.

First pair of lessons

Thinking skill	Reconstruction from partial evidence
Keywords	Discovering; bones

Science

Introduction to bones as scientific objects, drawing on the bones kept within the school science classes, if available.

Introduction to an actual fossil from a dinosaur or marine reptile, or a reconstruction as available *(provided).*

Class discussion: what are our emotional reactions to bones? Do these differ according to what animal they come from or how old they are?

Question and answer session to identify the processes by which bones change after an animal dies, including in fossilisation. *(Fact sheet on fossilisation provided.)*

Introduction of the notion of comparative anatomy, with a little history. *(Fact sheet provided.)*

Optional exercise: examine and measure bones from dead animals to produce a database. Draw graphs on bone sizes and position in the body and try to relate these to habitat, feeding habits, locomotion, etc.

Resources: reconstructed fossil bone, bones from school collections (if available).

History

Introduction to bones as historical artefacts, a different evidential status.

Reconstruct contemporaries' reactions to the discovery of remains of extinct creatures, exploring whether they were seen as real or fake, and how this depended on the perceived status of the people who found the bones. *(Fact sheet provided.)*

Exercise: detective stories. Reconstruct an account of early dinosaur finders from sets of partial evidence *(three packs provided).*

Resources: packs on each of three fossil hunters, each including a portrait, quotes from their contemporaries about them, quotes from historians about them, pictures of what they found, and pictures or information about where they lived or what became of them. Students will also need access to a museum with information on fossils, or reference books, or the internet.

Second pair of lessons

Thinking skill	Dealing with controveries in theory
Keyword	Mapping; geology

Science

Introduction to geology, as understood after the work of Lyell. *(Fact sheet provided.)*

Introduction to the notion of strata, including a revision of earlier coverage of the rock cycle.

Exercise: making sedimentary "rock" with Epsom salts. *(Instructions provided.)*

Exercise: drawing timelines representing important stages in the universe's development. On graph paper, this would be at least 5m long, and would not fit on human civilisation. A timeline from the creation of the sun to the emergence of human civilisation where the latter can just about been seen (represented by a line 1mm long) yields a time-line half a kilometre long.

Class discussion: how does geology challenge religion? Geology suggests that the Earth is much older than Christian doctrine maintained. Need science and religion combat one another this way? This may be left until after the timeline exercise for a more open-ended discussion about what it might mean for humans, to realise the incredible old age of the universe.

Resources: lots and lots of paper *(provided)* and a big open space.

History

Introduce the story of William Smith and his maps, and the debate over the rightful ownership of maps later issued by the Geological Society. *(Replicas of Smith's famous 1815 map provided.)*

Class debate: divide class into two groups, half to research William Smith's life and work and half to research the history and work of the Geological Society of London. Leads to a structured debate on whether or not it was right that the Geological Society published a map almost identical to Smith's without giving Smith credit for his work. *(Briefing sheets provided.)*

Exercise: edible geology. Class discusses the pros and cons of varying ways to represent strata, comparing two-dimensional representations (cross-sections and surface views of solid geology) with three-dimensional models. Children learn how the theory of superimposition means that one can read off what rocks lie under the surface from maps which represent only the top layer. Children make models from bread, butter, and sandwich fillings, and from three colours of chocolate, to represent the strata in the local area, using current geological maps *(provided)*.

Resources: briefing sheets, geological maps of the local area, strata recipes, and a hygienic work area if the students are to be permitted to eat the models they produce.

Third pair of lessons

Thinking skill	Explaining to others
Keyword	Representing; representations

Science

Present theories by which animals are reconstructed from complete or part skeletons, paying attention to muscle attachment points, the relation between muscle and power, the need to get the centre of gravity right (all part of biomechanics), and the function of skin and coloration.

Discuss how scientists and archaeologists also attempt to reconstruct behaviour from evidence of diet, migration, and reproduction habits.

The science of animation: how has science informed moving representations of dinosaurs, from the early twentieth century cartoon of Gertie the sauropod, to present-day CGI television programmes? Use video clips to show our current views of how dinosaurs moved through their environment, and to explain how these models have been developed.

Optional exercise: study a small set of present-day reptiles and birds (in life, on video, or via stuffed examples) for their posture, motion, and coloration, and embark on scientifically-informed design work for the future building of a model of the animal from which the original fossil (replica) came.

Alternative exercise: examine fossil leg bone from an iguanadon (if available through a Museum collection), and use this as a starting point for thinking about how to design and build a model iguanadon leg from wire, plaster, and paint.

History

Look at how dinosaurs and other extinct reptiles were represented in early and mid-nineteenth century England.

Consider developments in representations over the next 190 years to our present ideas of how these prehistoric reptiles looked.

Exercise 1: work from a set of eye-witness accounts of the Crystal Palace models to recreate the experience, in text or in pictures.

Exercise 2: piece together and order the history of changing representations of each of three dinosaurs (iguanadon, tyrannosaurus rex, and diplodocus) from images and contemporaries' accounts of models encountered and of the theories on which each representation was dependent.

Final activity

Thinking skill	Combining insights and negotiating.
Keyword	Building on

Museum visit and communal model building activity. This could take the form of building a scale model of an iguanadon leg from a chicken wire skeleton, through a mod-roc body, to a decorative skin. *(Craft materials provided.)*

The Bone Trail: stepping up
Alison Henning, March 2006



Photograph taken by Darren Hester, copyright Pixel Perfect Digital Inc. 2005.

Within the National Curriculum the pupils are given levels to quantify their attainment; this also gives teachers a clearer picture on what constitutes success and progress. In Year 9, the pupils are expected to achieve levels 5 and 6. Within level 6, pupils are generally expected to be able to interpret evidence, and to have a secure knowledge and understanding of their subject. The leap to level 7 is significant, as within level 7 pupils are expected to make predictions, use abstract thinking, and synthesise information from a wide range of sources.

The progression of thinking skills, then, moves from concrete thinking to abstract thinking. For example in chemistry, for a student to be recognised as working at level 6, he or she needs to demonstrate concrete thinking, for example by being able to classify materials according to their properties. A student with additional skills in abstract thinking, rising towards a level 7 standard, would be able to show that he or she had expanded on this knowledge to be able to use it to explain what happens within particles at a molecular level.

The activities which make up the Bone Trail project are designed to encourage just such a step up in thinking skills. We have tried to devise a set of challenges for children which are in themselves very concrete and specific, but which invite them to move up a layer in their thinking. Children may find that these lessons help to consolidate their existing knowledge and thus help them reach level 6, or, for the more able, to use their knowledge in new ways and reach level 7. The activities, therefore, span the range of learning preferences in order to offer opportunities for all children to discover their full potential as learners.

The Bone Trail: introduction
Emm Barnes
March 2006

Which subjects go together?

Can you think of things which connect together the different school subjects? Draw lines between subjects when you've thought of something that two have in common, or something that you can only do if you know about two subjects. For example, music is made up of notes which last particular amounts of time, which are measured in whole and half and quarter beats – relations expressed in fractions; so rhythm links music and maths.

How many connections can you think of?

Physics	English	Art
Chemistry		History
Foreign languages		Geography
Design and technology		Citizenship or PSHE
Maths	Music	P.E.

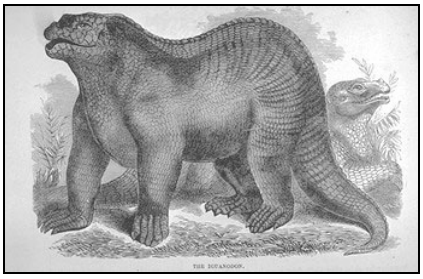
The Bone Trail: final activity
Emm Barnes, April 2006

Build your own dinosaur leg

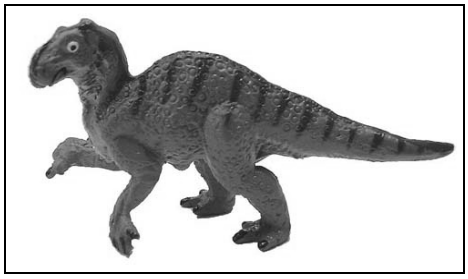
Before starting to make a life-size reconstruction of the back leg of an iguanadon, make sure you have a clear idea of what it should look like. These preliminary questions are to get you talking in groups, before you start your design work.

Did dinosaurs have legs like most modern reptiles or legs like mammals and birds? Did they move with their legs splayed out to the sides or straight underneath them?

In what position did iguanadon stand? Have dinosaur experts always thought it stood this way? Hint:



An illustration of iguanadon from 1859.



A model iguanadon from the 1990s.

If you enlarge a picture of a dinosaur by 100%, what happens to the area of the drawing – by what factor does it increase? What happens if you scaled up a 3D model by 100% – by what factor do its volume and mass increase?

If you have time, you can try an experiment. Using modelling clay, make a small rough model of some dinosaur. Measure its height and then build another twice as high and as similar in proportions as you can. Weigh the first model. How heavy do you think larger model will be? Now weigh the larger model – were you right? By what factor has the weight increased?

You're now ready to start your design work.

The Bone Trail: final activity
Emm Barnes, April 2006

Designing your model

1. Find a picture of the dinosaur you want to build; if possible, also find a picture of its skeleton. Measure how high the animal is in the images, and how long the leg is. Calculate the proportion of the leg length to the overall height of the dinosaur. Palaeontologists have noted that the usual proportion of length of a dinosaur's femur (thighbone) to the total length of the animal is 1 to 5. Does your finding agree?

2. Using research resources, find out how large iguanadon was in life. Work out the length of the leg from this information and from the calculation you did in stage 1. If you can, try to work out lengths for above and below the knee. If available, look at fossil iguanadon leg bones to check your calculation.

3. Take a boiled chicken leg. Pull the meat (the muscles) carefully away from the thigh bone and the lower leg bones, noticing how large the muscles are and the shape of them in relation to the bones – are they much fatter than the bones, and if so where on the leg? Where do they attach to the leg bones?

4. Using a tape measure, measure and record the girth of your leg around the top of your thigh, just above your knee, your calf at its widest point, and your ankle. What shape does your leg have? How does this compare with the length and width of your bones? Using research resources, find out how long and thick the leg bones of someone your age would be.

5. From your observations of the chicken leg and your own leg, and your calculation of the length of an iguanadon leg, draw a rough sketch of the shape of the iguanadon leg you are going to build. Make sure that it has big enough muscles to hold the animal up and help it move about!

6. Build a basic leg shape from modelling wire.

7. Wrap this in chicken wire.

8. Stuff the leg shape with scrunched up balls of newspaper.

9. Cover in strips of modelling roc, making three layers. Smooth the plaster into the holes in the gauze as much as you can to make a strong surface.

10. Allow to dry (roughly one hour) before painting with acrylic paint. What skin colour might an iguanadon have had? Why?

The Bone Trail: evaluation
Emm Barnes, April 2006

Students and teachers will naturally want to evaluate what they have gained from the activities which make up the Bone Trail. The team which developed the activities would also like to know what has worked well and what has been less successful in order to improve the resources.

Here are some suggestions for how you might like to evaluate the project. Please feed back your results to the BSHS, along with any other comments about the activities, by emailing outreach@bshs.org.uk. Thank you.

We suggest that the project be evaluated for its effects in one or more of five areas of possible learning: knowledge and understanding, intellectual and practical skills, attitudes and values, inspiration and creativity, and modification of behaviour, according to the goals of the teacher and the students set out before beginning the activities:

- evidence of increased knowledge and understanding might include greater understanding of the rock cycle and of animal anatomy, and deeper appreciation of Victorian attitudes to science and religion;
- evidence of learning in intellectual and practical skills might include an appreciation of the processes of theory construction in history and science, and conscious awareness of thinking and process skills;
- evidence of changes in attitudes or values might include contributions to debates about the nature of bones as scientific and historic artefacts and about an individual's right to credit for her or his work;
- evidence of inspiration and creativity might include an increase in enjoyment of three-dimensional modelling techniques, and an ability to visualise – to think of ways to make visible the import of – scientific facts and processes;
- evidence of modification of behaviour and progression might include an increase in team-working skills, and a display of greater confidence in presenting findings, ideas, and work to peers and adults.

Pilot schools have evaluated the Bone Trail resources in the following ways:

- students lead an assembly for peers in school about the project;
- students prepare a display of their work, including photographs of the geological timeline and models, and samples of the written work from the history activities, for mounting in school; students divide the work of preparing the display between themselves according to their individual competencies and preferences;
- students write about the activities in a blogspot hosted by their school;
- students are interviewed in groups before and a month after the activities to see if attitudes to history and/or science have changed.

The Bone Trail: further resources
Emm Barnes, April 2006

The following books are easy to obtain by mail order and cost less than £25.

For children

"Stone Girl, Bone Girl" – Laurence Anholt, illustrated Sheila Moxley (Corgi, 2000, ISBN 0552545996)

"Scientists Anonymous: Great Stories of Women in Science" – Patricia Fara (Wizard, 2005, ISBN 1840465743)

"Geology Rocks!" – Cindy Blobaum and Michael P. Klein (illustrator) (Williamson, 1999, ISBN 1885593295) (lots of practical activities to explain principles in geology, including making "fossil bones" from sponges and epsom salts, and making "sedimentary rock")

For teachers

"The Dinosaur Hunters: A True Story of Scientific Rivalry and the Discovery of the Prehistoric World" – Deborah Cadbury (Fourth Estate, 2001, ISBN 1857029631)

"Victorians and the Prehistoric: Tracks to a Lost World" – Michael Freeman (Yale Uni Press, 2004, ISBN 0300103344)

"Archetypes and Ancestors: Palaeontology in Victorian London, 1850-1875" – Adrian Desmond (Uni of Chicago Press, 1984, ISBN 0226143430)

"Models: The Third Dimension of Science" – Soraya De Chadarevian and Nick Hopwood (editors), the chapter by Jim Secord on the Crystal Palace models (Stanford University Press, 2004, ISBN 0804739722)

"Earth Time" – Douglas Palmer (John Wiley and Sons, 2005, ISBN 0470022213)

"The Map that Changed the World: A Tale of Rocks, Ruin, and Redemption" – Simon Winchester (Penguin, 2002, ISBN 0140280391)

Online

Legacy site for 1997 exhibition "Paper Dinosaurs, 1824 – 1969" at the Linda Hall Library: http://www.lindahall.org/events_exhib/exhibit/ex_paper_dino.shtml

Information on the life of the Anning family, and its connection with Jane Austen: http://www.jasa.net.au/seaside/morelyme.htm

Biography of Mantell: http://www.dinohunters.com/Mantell/Dates.htm The site's homepage, http://www.dinohunters.com/, has links to pages of information on many other "dinosaur hunters".

On the parts of Britain rich in Jurassic fossils: http://www.livingarchive.org.uk/bluelagoon/docs/geology.html

For a set of activities to support design work for building model dinosaurs: http://scienceworks.museum.vic.gov.au/pdf/TerrorsaurusKit3.pdf