

Introduction to geology and palaeontology

Weekly 2-hour sessions at £100 per term (10 weeks)

Starting January 11th 2018, 2-4.30ish (TBC!)

Venue: Chatsworth, Spa Road, Llandrindod (Radnorshire Museum if more space is needed)

Beneath the surface of our world is a much older and more mysterious one. It is revealed by the evidence found in the rocks, from traces of volcanic eruptions to the fossils of ancient life. This course aims to guide you in learning to read these hidden records. No previous knowledge required.

Term 1: the basics

1. The Earth: structure, continents and tectonics

Origin, composition and structure of the Earth; formation of continents; plate tectonics and landscape

2. Time: an outline of Earth's past and major events in the history of life

Summary of the past 4.5 billion years, including major transitions in life; Precambrian life; atmospheric oxygen; Phanerozoic biodiversity

3. Local geological history: the Welsh Basin

Cambrian to Carboniferous Wales: formation of the Welsh Basin, then inversion in Caledonian orogeny.

4. The Rock Cycle: igneous, metamorphic and sedimentary rocks

How rocks are formed, transformed and recycled, and how to recognise the different types.

5. Interpreting sedimentary rocks and palaeoenvironments

Using modern sedimentary environments to help interpret sedimentary rocks; grain size and shape, sedimentary structures and chemistry.

6. Chemistry and minerals

Dissolution, crystallisation and chemical equilibria are critical to geology and especially palaeontology, and a basic knowledge is essential; the commonest minerals; biomineral skeletons and what happens to them.

7. Geological dating

Correlation and absolute dating: the principles of isotope dating, chronostratigraphy, lithostratigraphy and biostratigraphy.

8. Fossils: the basics

What fossils are, and what they represent. What they can tell us, and what they can't.

9. Evolution

The principles of biological evolution by natural selection, and the New Synthesis. How it works, why it works, and where the uncertainties still remain.

10. Diversity of life

The Big Picture of the tree of life; major groups of organisms, and relationships of major animal

groups; how to define diversity, and what encourages it.

Term 2: major groups of fossils

This term will focus each week on particular groups of fossils, and explore aspects of palaeontology that are particularly related to them.

1. Trilobites: moulting and microevolution

The iconic Ordovician fossils: diversity, biology and ecology. Growth of organisms with rigid exoskeletons. Studying small-scale changes in evolution through a rich fossil record.

2. Graptolites: biostratigraphy and baffling life habits

Both planktonic and benthic groups, with contrasting evolutionary fortunes. Debates over floating versus swimming, and other issues.

3. Brachiopods: the secrets of their success

Perhaps the most successful Palaeozoic animals; the major groups and their basic biology. Living fossils in a long, slow decline; competition between major groups.

4. Molluscs: ultimate adaptability

From limpets to octopus, the molluscs show what can be achieved within one basic body plan. Ability to adapt, defend themselves and colonise almost any habitat. Early environmental preference for shallow seas.

5. Bryozoans and corals: a colonial life

Identification and methods of study in colonial animals. Reefs and hardgrounds in the fossil record, and their effects on the surrounding ecosystem.

6. Echinoderms: Weird, wonderful and then some more weird

A unique body plan with a unique history; recognising shared traits of different echinoderm groups, and piecing together their relationships to each other. Taphonomic bias in the fossil record, and destruction of multi-element skeletons.

7. Sponges: a simple life

Filter-feeding machines with a distinctive skeleton. Supposed to be the most ancient living animals, and the simplest... but is it a sham? A detective story.

8. Ostracodes and other arthropods

The other relatives of trilobites, from millimetre-sized ostracodes to three-metre-long sea scorpions. Evolution in an armoured skeleton, and the potential of having legs.

9. Early vertebrates

The first fish (including conodonts), and as far as their transition onto land. Recognising fragments of the major groups, and the effects of jaws on their neighbours.

10. Microfossils: the unseen world

The extraordinary world of miniature fossils, from acritarchs and diatoms to Small Carbonaceous Fossils. Processes for extracting them and studying them, and what they can tell us.

Term 3: Aspects of palaeontology

This term delves more onto the principles, phenomena and controversies in palaeontology, building on the basic background information put together in the previous terms.

1. Taphonomy and biases

How preservation affects different groups in different ways, and how this can affect how we see the fossil record.

2. Exceptional Preservation

The processes of soft-tissue preservation and other exceptional fossils, and how these can reveal whole new worlds, and also introduce new biases. Repeating styles of exceptional preservation through time, dependent on geography and climate. How to search for more of these sites.

3. Stem groups, crown groups, and the classification of life

Linnean classification, and phylogenetic classification; how we define species and higher-level groups; how to map evolution into a hierarchy, and how it has led us astray.

4. Palaeoecology introduction

The interactions between organisms and their environments, from simple predator-prey relationships to competition, efficient resource use, and nutrient flow. Adaptations to cruel and unusual ecology, and interpretation of fossils' ecology based on their form.

5. Mass extinctions

The Big Five: ice ages, climate change, volcanoes and asteroids. What happens when the world goes haywire, and how does life adapt? How do creatures survive an extinction event, and does the ecosystem rebuild itself afterwards?

6. Modes of Evolution: Molecular clocks, Punctuated Equilibrium and Phyletic Gradualism

How evolution looks in the fossil record, and separating real patterns from artefacts of geology and genetics.

7. Ediacaran Biota

The great Precambrian enigmas. Are these the ancestors of living animals, or a separate evolutionary experiment? At a time when we should (theoretically) be seeing the earliest animals, what are these telling us about the origins of complex life on Earth.

8. The Cambrian Explosion

The appearance of unambiguous animals in the fossil record, with almost every phylum appearing in a geologically short interval. Is it an explosion of life, or an explosion of fossils? What are the possible causes, and how can we narrow down the options?

9. The Ordovician Radiation (GOBE)

After the Cambrian Explosion, the Great Ordovician Biodiversification Event—even bigger, and just as strange. Unlike the Cambrian, diversification was at lower taxonomic levels, and on different spatial scales; it was an ecological revolution as much as an evolutionary one. But what drove it... if anything?

10. Astrobiology: something completely different?

Finally, there is the hope that life on Earth isn't unique, and that we may one day be finding at least the fossils of creatures on other worlds. This is the study of possibility; of what life can achieve, and what its limits are; of evidence and ambiguity, and why chemistry is often our best line of investigation... until we can get there ourselves.