fusion Working on behalf of HS2

L-P ARCHÆOLOGY

Dig-ital Resource pack

The Science of Archaeology (KS3 - KS4/ Secondary) (Science)

LESSON INFO :

A Key Stage 3 & 4 workshop on the scientific investigation undertaken as part of archaeological assessment. Addressing how archaeological materials are recorded, analysed and dated. It is designed to encourage critical thinking and promote evaluation of scientific thought. It includes exercise in the application of scientific techniques used to test a hypothesis in the archaeological field.

The lesson focuses on the archaeological remains of St Mary's church found near to the village of Stoke Mandeville in Buckinghamshire. The ruins of the former parish church, and the area immediately surrounding it, are currently undergoing archaeological investigation as part of the HS2 project. The lesson encourages thinking about changes made over time to the land and lives of people who lived here.

Objectives -

- To address how materials are archaeologically investigated
- To ask questions about the archaeological process
- To evaluate archaeological materials
- Understand the application of scientific study to archaeological materials

Teacher objectives -

To encourage discussion about the process of archaeology and explore questions regarding the use of modern scientific methods in the investigation of historic / ancient remains of past human settlement. Direct discussion on the incorporation of STEM subjects within archaeological investigation.

Students Will:

Consider their local historical environment and what remains of past populations who inhabited it. Make observations regarding the value of excavated materials to archaeological investigations and the opportunities within the heritage industry applied through STEM subjects.

Provided resources:

Science of archaeology exercise

You will need :

Classroom board
Scissors

Estimated time : 40 min

This workshop would greatly benefit from a virtual follow up 'meet the archaeologist'.

Introduction

Archaeologists are currently working on behalf of HS2 to excavate the ruins of St Mary's Church in Stoke Mandeville. They are uncovering a wealth of archaeology that will tell us more about the history and past communities of Stoke Mandeville. The church and churchyard of St. Mary's is one of the most important historical sites being investigated along the route, and we hope that the archaeological work will answer many questions about the building and its surrounding landscape.

The church of St Mary the Virgin was built in the late 11th century, shortly after the Norman Conquest in 1066. Unlike the modern church, also called St Mary's, the old church was not located in the centre of the village. Instead it stood in the middle of an agricultural landscape, on land owned by the bishop of Lincoln. Near to the church there were a number of other buildings, like barns and a mill. The mill is mentioned in the Domesday Book, which lists information about who owned land in England after the Norman Conquest.

The church was built in the bottom of a shallow valley, which was naturally very wet. People working the land in the medieval period took advantage of this, creating a number of artificial streams and ponds. These provided water to the nearby mill and were later used for growing watercress.

When the new church in the centre of Stoke Mandeville was opened in the late 1800s, St. Mary's fell into disrepair, although the churchyard continued to be used for burials until 1908. The ruins became dangerous and unstable, and the church was eventually demolished in 1966. In total the church and churchyard were used for over 800 years. The landscape around the church has evidence for even longer habitation. Excavations have also been taking place at the site of a Roman settlement to the east of the church, where buildings were arranged on either side of a central trackway. This settlement appears to have earlier Iron Age origins. High status Roman finds, such as a coin and decorated pottery, suggest that a Roman villa may have stood nearby.

As well as these packs for schools, we have a Field Museum on site, over a number of weekends over the summer. Inside the museum is a viewing platform giving a view of the ongoing excavations, as well as displays, films and interactives enabling you to explore the history of St. Mary's church and find out about archaeological discoveries in the area. Come and see the excavations, meet the archaeologists and find out more!

Background :

What is archaeology and what do archaeologists do?
(Ask the class this - open it up for discussion for c.5-10 min. Perhaps draw a mind map of ideas on the classroom board or provide paper for groups to draw quick maps of their own ideas. Note archaeology is very different to paleontology which is the study of fossilised animal remains i.e. dinosaurs!)

Archaeology is the scientific study of the material remains of past **human** life and activities.

It is often considered to be both a science and a humanity. It draws skills from a range of subjects such as history, geography, biology, chemistry, maths and computer science, to name a few. It is a multidisciplinary subject that incorporates a broad range of skills, ideas and methods. It is also divided into sub-disciplines such as; osteo (bones), environmental, experimental, forensic, maritime, landscape, battlefield and digital archaeology.

Archaeology developed from 'antiquarianism' in Europe during the 19th century. The term 'antiquarian' derives from latin and means enthusiast or student of antiquities / things from the ancient past. Since the 1800's the discipline has developed into a subject of both the sciences and humanities. Though archaeology has its origins in the Victorian period it has since adopted the modern scientific method. Principles from Science, Technology, Engineering and Maths (STEM) are used by archaeologists everyday to study the remains of past human lives.

Archaeologists today study the remains of past human life from the development of the first hand-tools c.3.3 Million years ago until the modern day - even things such as a memory stick has been added to a museum having been found as part of an archaeological excavation! The goal for archaeologists is to understand the cultural history of past people and be able to explain change or continuity in the use of an area over time.

Archaeologists survey, excavate and analyse data collected to learn more about the past in a scientific manner.

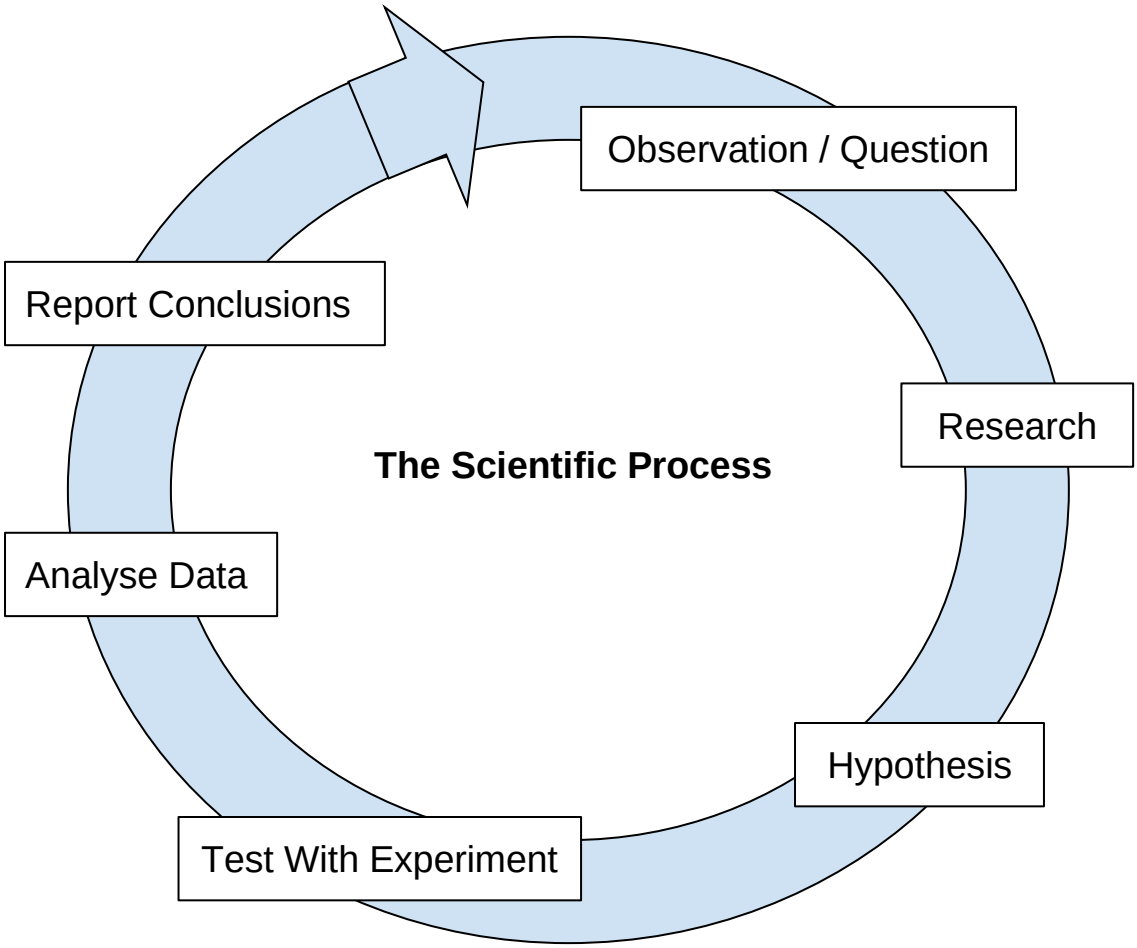
In this workshop you will be asked to think like an archaeologist and consider the application of scientific principles and methods to the excavation and research being undertaken by archaeologists in Stoke Mandeville, Buckinghamshire.

What is the '*Scientific Method*' and how does it apply to archaeology?

(Ask the class to consider how they hypothesise and draw conclusions in science and the pattern of investigation they follow. Spend c.5-10min discussing this. The cyclical diagram below can be drawn out on the board and students asked if they can fill the gaps.)

Scientific Method - a method of investigation in which a problem or question is identified through observation. Research is then used to construct a hypothesis (a statement that may be proved or disproved) which is tested through experimentation or other form of data retrieval. Analysis of data leads to conclusions that either support or oppose the hypothesis and usually leads to further questions or problems that warrant further investigation, making the method theoretically circular.

- *Think about how you conduct experiments in chemistry, biology or physics but also how you answer questions in subjects like geography or history when asked to debate and consider a statement and whether you agree with it, how you use information and data to support your argument and draw conclusions.*


Observation / Question
Research
Hypothesis
Test With Experiment
Analyse Data
Report Conclusions
The Scientific Process

How do we use the scientific method in archaeology?

Archaeologists use the scientific method in their approach to investigation. Observing a possible new location for archaeological remains to be found or questioning what we think we know about life in the past. From this they follow a process of research, using historic documents, maps and photographs or even evidence from previous excavations of a location to understand the potential archaeological materials left in that area. This research is compiled into documents called Written Schemes of Investigation (WSI) before preparations for archaeological work in the field is planned. From this research they develop a hypothesis, what they expect to or could potentially find. They form questions about past people and populations that they hope to answer through archaeological investigation; collecting a range of data to test their hypothesis with.

What type of hypothesis / questions do you think archaeologists are trying to answer in their excavation of the ruins of St Mary's church in Stoke Mandeville?
(Ask the class to think of a few examples and write them on the board, use information within the introduction to help you)
E.g. -

- *How long have people lived in this area?*
- *Why was the church built there?*
- *Why was there not a medieval village built around the church?*
- *What type of farming / agriculture were people in the past doing in Stoke Mandeville ?*
- *Was there a Roman settlement nearby ?*
- *Who was living here?*

What is archaeological science?

Archaeological science is the development and application of scientific techniques to the analysis of archaeological materials. The methodologies of archaeological scientists encompass a broad range of sciences including, physics, chemistry, biology, medicine, geology, geography and material science. There are a range of techniques and scientific instruments used by archaeologists in their investigations. In the following exercise you are asked to think like an archaeological scientist and consider what would be the appropriate methods to use when investigating a specific archaeological site

Exercise 1: The Processes of Archaeological Investigation

(*Get the class into small groups to work in teams to complete this exercise, they are asked to think of themselves as the archaeological project managers planning an archaeological excavation. They are to choose what scientific processes and methods they would employ during their investigation. In doing so they will learn about the range of scientific methods used before, during and following excavation.)*

In small groups imagine that you are incharge of organising the archaeological investigation of a former parish church that was left in ruins 100 years ago, just like the one being excavated in Stoke Mandeville. Think about the type of archaeology you are likely to come across when investigating the ruins of a church and its churchyard as well as the large field surrounding it.

A brief description of your site for investigation;

> "The ruins of a church sits in the middle of a field in a small, shallow valley to the south of a rural village, it is a marshy and wet location. The church is thought to date to around the 11th century, according to research using historic maps and documents, but has not been in use for over 100 years because it collapsed and now looks to be a large pile of rubble. There may be parts of the walls still standing beneath it. There are no trees in the area but the site has tall grass growing over most of it. In the rubble, and in the area immediately around the former church there are several headstones and grave markers. Finds in the surrounding field include; roman coins and a roman spear, earlier iron age pottery and some medieval belt buckles. No previous archaeological excavation has even been undertaken here"

Your challenge is to plan the process of investigation, under the framework of the scientific method, and to make sure that you collect enough data so you can draw conclusions and answer your hypothesis. Some of the scientific methods available are not suitable to be applied to this site - work out from the description of the site which ones will provide you with meaningful data for your investigation. Of the methods you wish to employ in your investigation. Organise them into piles according to the order you would use them in either as part of your 'preliminary investigation' (before excavation) or as part of 'post-excavation analysis' (after excavation/ in the laboratory).

Stable Isotope Analysis / Radiocarbon Dating
Chemistry

Isotopes are atoms of the same element that have an equal number of protons and unequal number of neutrons, giving them slightly different weights. Radioactive isotopes, such as Carbon-14, decay over time at a measurable rate. As we grow we absorb different isotopes through the food we eat and the water we drink. It is possible to determine what climate zone or environment (e.g. coastal or inland) someone once lived in by analysing their bones. It has become a well-established technique for investigating diet and mobility in past populations. Isotope ratios are measured using analytical instruments known as isotope-ratio-mass–spectrometers (IRMS).

DNA Analysis
Biology

The genetic information of an organism is contained in the deoxyribonucleic acid or DNA, within the nucleus of a cell. Genetic sequencing of animals, plants and humans has a range of benefits to an archaeological investigation. It can help us understand past human populations and can even identify if two individuals were related. It can also help to identify the sex of an individuals by analysing the 23rd pair of chromosomes that determine if someone is male of female. In animals it helps to identify the species that an excavated bone belonged to and can even show if an animal or plant was domesticated or wild!

Ground Penetrating Radar (GPR)
Physics

A geophysical method of investigation that uses radar pulses to image the subsurface. The GPR unit is pushed across the ground on a trolly-like frame in a linear pattern. It is non-intrusive and works by transmitting an electromagnetic pulse into the ground at regular intervals. These pulses reflect off features in the ground, like buried walls, and are detected by a receiver antenna. Collecting GPR data across an area allows for the mapping of buried features, giving an estimate of size, shape, and depth by measuring the strength and delay on radar waves reflecting off hidden archaeological features.

LIDAR (LIght Detection And Ranging)
Physics

LIDAR can be used to make 3D models of the earth's surface. It is used to measure variable distances by targeting an object or surface with a laser and measuring the time it takes for the reflected light to return to the receiver. It is commonly used to make high-resolution maps by flying a mobile LIDAR unit attached to a drone or airplane above the area of investigation. It generates a highly accurate map that can chow depressions or rises in the ground and show where previous buildings or earthworks once were that may now be covered in dense vegetation and be unseen from the ground or with the naked eye.

Magnetometry
Physics

Magnetic survey is one of a number of methods used in archaeological geophysics. It is used to detect and map archaeological features buried beneath the ground using a magnetometer. Every kind of material has unique magnetic properties - even if we don't not think of them as magnetic. For example burnt materials, like that where a fire pit or hearth once had been, causes very subtle disturbances in earth's magnetic field that can be detected by sensitive receptors in the magnetometer. Magnetic survey helps to provide data that indicates where areas of potential archaeology might be.

Dendrochronology
Biology

Dendrochronology or tree-ring dating is the scientific method used to date the age of a tree. A tree's growth rate changes in a predictable pattern throughout the year in response to seasonal climate changes, resulting in visible growth rings. Each ring marks a complete cycle of seasons, or one year, in the tree's life. Dendrochronology produces a precise date/ age rather than a range of measurements like radiocarbon dating produces. As well as providing the age of the wood it also provides data on the climate and atmospheric conditions that the tree lived in through a parallel science called dendroclimatology.

Potassium-Argon Dating
Chemistry

A method of determining the time of origin of rocks by measuring the ratio of radioactive argon to radioactive potassium in the rock. It can be used in archaeological settings to date fossilized remains, for example hominin remains associated with volcanic sediments especially.

Mass Spectrometry
Chemistry

A technique used to measure the mass-to-charge ratio of ions (a positively or negatively charged atom or molecule) of a material. A sample of a material is first ionized by bombarding it with a beam of electrons, ions are then separated according to their mass-to charge ratio. The results are typically presented as a 'mass spectrum'. Mass spectrometry is used in many different fields and is applied to pure samples of elements as well as complex mixtures. Its primary use is to determine the atomic makeup of a material investigated. For example to understand the mixture of metals in an artefact made up of an alloy.

Historical Environment Sampling
Biology

Samples from individual archaeological deposits are taken and analysed for plant and animal remains. These are usually recovered by a process called 'flotation' where bulk (40 Litre buckets) of soil samples are placed on an extremely fine mesh suspended in water that allows heavy sediments to sink while shells, bones and charred plant remains float to the surface and can be collected for analysis. Often the remains of seeds are found and provide evidence of the plants that once grew.

Ceramic Petrology
Chemistry

Microscopic examination for studying pottery or other clay objects that contain minerals of geological origin. By examining a small cross-section under a microscope scientific archaeologists can analyse the inclusions of miniscule geological deposits to determine where the clay used to make the bowl, jar or other object originated by comparing it with a database of geological deposits known to have been used by past populations to make pottery.

Metallography
Chemistry

Microscopic examination for studying metals, metallography is the scientific discipline of observing and determining the chemical and atomic structure, grain and inclusions or phases in metallic alloys. It can clarify the kind of mold used to cast a metal object and distinguish between cold-worked and cast objects because of the differences in crystalline structures; these can be severely distorted if flattened by a hammer or in a more organised structure.

Side-Scan Sonar
Physics

A sonar system that is used to efficiently create an image of large areas of the sea floor. It is used to conduct surveys for maritime archaeology. A sonar device emits conical or fan-shaped pulses from the side of a vessel or mounted to a ship's hull. The intensity of these acoustic waves reflecting off the seafloor or anything lying there is recorded in a series of slices. When digitally stitched together along the direction of motion it can produce an image of the seafloor.

Resistivity
Physics

Resistivity is a form of geophysical survey. Electrical current is passed through the ground at regular points on a survey grid. Electrical resistance in the soil varies, and is affected by the presence of archaeological features. Electrical currents are conducted through the soil by mineral salts contained in water - the moisture content is therefore essential to the level of resistance in the soil. The patterns of resistance in the soil are recorded, plotted and interpreted to create a map of potential archaeological features in a surveyed area.

Teacher notes : Exercise 1 answers

Preliminary investigation (before excavation)

- **Ground Penetrating radar** (gives good indication of the archaeology likely to be found through excavate; where and a what depth, needs to be done prior to excavation to help inform archaeologists where to dig)
- **LIDAR** (indicator of where archaeology is likely to be found in a wide area, needs to be done prior to excavation to inform where archaeologists should investigate. Can argue that we are only looking at a small area so this isn't essential but would still provide useful information)
- **Magnetometry** (used to indicate where potential archaeological deposits might be prior to excavation)
- **Resistivity** (used to indicate where potential archaeological deposits might be prior to excavation, the level of water in the soil makes this method viable)

Post-excavation analysis (after excavation)

- **Radiocarbon dating** (needs to be done in laboratory settings, investigates the remains of animals or humans by analyzing their bones - after they are excavated)
- **DNA Analysis** (needs to be done in laboratory settings and after the organic remains have been excavated and cleaned)
- **Ceramic petrology** (needs to be done in laboratory settings and after ceramic finds have been excavated and cleaned)
- **Metalollogy** (needs to be done in a laboratory setting after metal finds have been excavated and cleaned)
- **Mass Spectrometry** (needs to be conducted in a laboratory setting, helps to determine the materials found through excavation)
- **Historic Environment Sampling** (uses materials from excavation to be studied in a controlled environment and often needs microscope to analyse the remains of past floral matter)

Not suitable for this investigation

- **Dendrochronology** (no trees on this site so unlikely to be necessary, possibly all been cleared so the field could be farmed at some point in the past. Can be argued that wooden materials could be found during excavation - wet conditions preserve wood well but it's unlikely any wooden fragments would have enough rings to be suitable for dendrochronology or provide any valuable data through this method.)
- **Potassium Argon Dating** (finds from this site not old enough to be fossilised and not associated with volcanic deposits)
- **Side Scan Sonar** (only applicable to maritime conditions, though it is a wet area it is not deep enough water to undertake this method of investigation)

Conclusion:

Ask your students to reflect on the work they have done during this workshop. If there was anything surprising or interesting they found out. How many would have considered archaeology as a science?

Archaeology is an ever evolving subject and as new scientific advances are made more scientific techniques are being applied to the study of the past. The scientific methods looked at here are but a handful of those employed within investigation. Can you notice a pattern in those that are commonly undertaken before excavation and those that occur after? Preliminary investigation tends to be non-intrusive whereas post-excavation relies upon material having been removed from where they were found to be studied.

To investigate difficult environments, such as underwater or even in space, an array of technology is employed by archaeologists. How does the application of the scientific method and methods of data collection differentiate archaeology from other forms of historic studies? Do you agree that it is the application of science that separates archaeology from 'treasure hunting' as it collects a range of data about the past through preliminary investigation, archaeological excavation and post-excavation processes that has no monetary value but can provide us with a rich understanding of the past?

Computer science is one of the new great frontiers in archaeology - as it is in most disciplines and businesses. As the use of computers ever increases, archaeology is becoming increasingly digitised - especially in how archaeological data is recorded and stored. At the excavation of St Mary's in Stoke Mandeville a technique called photogrammetry is being used to record in detail important archaeological deposits and finds. Photogrammetry involves taking a number of geographically referenced and scaled images of an object from all angles. Processed through computer software these photos are stitched together to form a textured 3D digital model of the photographed object. This technique has been used by a number of museums to create a range of virtual museums!

Homework ideas -

- Produce a poster on the use of a scientific instrument / method used in archaeology; how it works and how it is applied to archaeological investigation. This can be one discussed here today or another relating to terrestrial or maritime archaeology.
- Write a 250 word encyclopedia style entry on ‘archaeological science’ or ‘digital archaeology’.
- Produce three more cards in the style of the learning exercise on three different scientific archaeological techniques. Research different methods and write a short description of each that can be added to this exercise e.g photogrammetry.