Feder Chapter 2
(Pp. 24-47 & 52-59)

Probing the Past
This chapter is all about **archaeological epistemology**: the archaeological methods we employ to illuminate the human past.

Archaeologists and paleoanthropologists apply a broad array of techniques in their investigation of the human past.

This chapter briefly surveys some of the more important procedures for recovering and analyzing the data on which the rest of the book is based.

**The “science” in the study of the past**

Science is a process of understanding phenomena through observation, generalization, verification and refutation.

All scientists look for patterns:

- **Inductive approach**: Observation → pattern → hypothesis → theory
- **Deductive approach**: Theory → hypothesis → observation → confirmation

At the same time, scientists are informed by paradigms: Overarching perspectives.

- Associated with paradigms is the concept of a paradigm shift (radical theoretical shift, Thomas Kuhn) wherein a society shifts to a new worldview.
- In science some examples include: 1) Newton’s laws (classical mechanics); 2) Mendelian genetics; 3) evolution by natural selection; and 4) germ theory of disease.


Archaeology and paleoanthropology pose special problems because data are ancient, elusive, and rare.
How sites are formed, how they are preserved, and how they are discovered are key questions for archaeologists and paleoanthropologists.

Archaeological sites are the places where people lived and carried out tasks, and where they made, used, discarded, secreted, or abandoned stuff. Sites are the equivalent of the fossils of extinct animals.

Sites represent the physical remnants of the hardware left behind by a people and a culture. In other words, sites consist of the material remains of a way of life.

- **Artifacts** are tangible objects; anything that was made or modified by people in the past qualifies as an artifact.
- **Ecofacts** are the natural materials that give environmental information about a site. This includes plant and animal remains discarded as food waste, and pollen grains in the soils.

How sites are formed

In paleoanthropology, **taphonomy** is the study of how bones and other materials came to be buried in the earth and preserved as fossils.

- Taphonomy helps explain the nature of the fossils uncovered.
- A taphonomist studies the processes of sedimentation, the action of streams, preservation properties of bone, and carnivore disturbance factors.
- Think about how differently a specimen would if a person were buried, or killed and dragged for by a predator as food.
- Perhaps the most famous example (at least for those who read mystery novels) is the Body Farm.
• How sites are formed (continued)
  • A feature is a combination of artifacts and/or ecofacts at a site; infers a location of some human activity.
    • Activity areas are places where groups of activities are carried out, but where then altered into archaeological sites over time.
    • Examples include 1) kill sites; 2) villages, and 3) stone quarries.
  • In archaeology, sites are defined not only but what is found, but also their context.
    • Context describes the spatial and temporal associations existing in the archaeological record among and between artifacts and features.
      • Primary context (deposited with primary refuse) is the setting in which the archaeological trace was originally deposited.
      • Secondary context (deposited with secondary refuse) is one to which materials have been moved.
  • Provenience is the 3-D location of an artifact in the dig. The location, and its proximity to other artifacts (associations) tells about the context of the physical remnants.
Sites 3

- **How sites are preserved**
  - Natural process may cover, protect, and preserve sites:
    - In part, this goes back to taphonomy.
    - In part, this is a question of geology.
  - Feder uses the example of Pompeii (and Herculaneum) as a way to illustrate this point.

- **How sites are found**
  - Sometimes it is obvious (think pyramid) Other times it takes more work to find a site.
  - Survey work may include:
    1. A *pedestrian surface survey* (walkover survey), simply looking for sites exposed on the surface.
    2. Scanning aerial photographs looking for surface indications of a site.
    3. **Test pitting**, the excavation of small soundings in an attempt to find buried material.
    5. Remote sensing; using radar or electrical impulses to find buried material.

- Pictures: Survey work on [Rapa Nui](#) and test pit.
Non-invasive methods of data collection

Sites are investigated through excavation.
- In excavation we expose, record, and usually remove material for further analysis.
- But, excavation, is by definition, invasive. All this means that excavation is only done when necessary.

In recent decades, a set of non-invasive methods have been incorporated into archaeology. Examples include:
- Ground penetrating radar (GPR) emits an electromagnetic pulse into the ground.
- The fluxate gradiometer measures minor fluctuations in the Earth’s magnetic field (potentially due to soil alterations).
- One of the most exciting newer tools used in archaeology is called LiDAR (Light Detection and Ranging).
  - It uses laser light to measure differences in distances.
  - One example of its use was the modern forests of New England.
  - Another example of its use is in the Mayan jungles.
- 3D laser scanning is another technique.
  - This one allows for the 3D reconstruction to a level of detail not before available
  - Watch Time scanners for several examples of how used.
Once found, data can be analyzed to determine the age of the sites, how raw materials were obtained, how tools were made from those raw materials and how they were used, on what foods was subsistence based, and aspects of a people’s social, political, and even religious lives.

Archaeologists create types; categories of artifacts that share selected characteristics. There major types of types are:

- **Morphological types**: The common attributes are size, shape and color. Does not assume the functions of the objects.
- **Functional types**: Looks for evidence of use. Examples would be food residue in pots or microwear (marks left from the use of the tool) on lithic blades.
- **Temporal types**: Artifacts go through stylistic changes over time. Examples are changes in pottery styles, tool types and so forth over time.

In archaeology there is a tension between discussions of form and of function.

**Trace-element analyses** determine the source of the materials used. Focuses on chemistry and geology.

- One type of trace-element analysis, **neutron activation analysis (NAA)**, traces the chemical signature of the raw material used.
  - Both organic and inorganic samples have been tested when targeted with a neutron stream.
  - Read more here, if interested: [http://archaeometry.missouri.edu/naa_overview.html](http://archaeometry.missouri.edu/naa_overview.html)
- **X-ray fluorescence (XRF)** also looks at the chemical composition by exciting atoms with an external energy source and measuring the x-ray photons emitted.
  - Measures inorganic samples
  - Read more here: [http://archaeometry.missouri.edu/xrf_overview.html](http://archaeometry.missouri.edu/xrf_overview.html)
Analyzing Archaeological Data 2

- **Tool manufacture and use**
  - Tool usage can be ascertained from morphology and from wear patterns (such as striations, polish, and scars).
  - One way to ascertain and then study how tools were made and used is through replication in the approach called **experimental archaeology**.

- **Social patterns: How ecofacts are analyzed**
  - **Osteological samples**
    - Many researchers have a bone library (more formally called osteological comparative collection).
      - I remember a close friend of mine had the work study job of boiling the flesh off of roadkill to expand our professor’s bone library.
      - These samples help: 1) with species identifications, 2) with determining MNI (minimum number of individuals) in a faunal assemblages, 3) with determining traits indicating sexual dimorphism and 4) with osteological development stages (ageing a specimen).
    - Others study **coprolites**.
  - **Size of fossils**
    - Most of our understanding of human plant use has come from the study of macrofossils (preserved seeds, fruits, nutshells, or other residue large enough to be seen with the naked eye).
    - Plant **microfossils** are another important source of data, often retrieved by flotation.
      - **Palynology & pollen**: Microscopic grains containing the male gametes of seed-producing plants.
      - **Phytoliths**: Microscopic silica structures formed in the cells of many plants.
      - **Starch grains**: Subcellular structures that form in all plant parts and are classifiable by family or genus; particularly abundant in seeds and tubers.
Analyzing Archaeological Data 3

- **Blood residue**
  - Blood residues have preserved for millennia.
  - Just like in forensics work, the species can be determined.

- **Carbon isotopes**
  - All plants use photosynthesis, but they may use the **C3 pathway** or the **C4 pathway** when they extract the carbon from the C0₂ (carbon dioxide) they respire.
    - The C3 pathway is commonly used by trees \(^{13}\text{C}\) is filtered out
    - The C4 pathway is commonly used by most grasses and sedges, and \(^{13}\text{C}\) is more easily used.
  - As a result of these differing pathways, carbon isotope analyses can aid in environmental and dietary reconstructions.

- **Oxygen isotopes**
  - Climate changes can be noted in the fossil shells of ancient foraminifera.
  - Specifically, the ratio of \(^{16}\text{O}\) and \(^{18}\text{O}\) are affected by climate.
    - In colder times, \(^{16}\text{O}\) is lowered.
    - The ratios across time have been plotted for the last 780,000 years.

- **Skeletal remains**
  - Human and pre-human skeletons are analyzed by: 1) Species; 2) sex; 3) age at death; 4) geographic origin, and 5) pathology and disease.
  - Read more in book.
The oldest relative dating method is stratigraphy (study of sequential layering of deposits).
- It is based on the principle of superpositioning.
  - In a stratigraphic sequence, the lower layers were deposited before the upper layers.
  - A layer is called a stratum is a single layer of soil or rock; sometimes called a level.
- Closely connected to geological stratigraphy is the method called biostratigraphy (also called faunal correlation).
  - This relative dating technique is based on regular changes seen in evolving groups of animals as well in the presence or absence of particular species.
  - When a chronometric date of certain fossils are known, these index fossils can be used to estimate the age of the layers in which they are found in a new location.
- This same concept of applying dates from known objects to sites of unknown ages is also used for features and artifacts and the technique is known as cross-dating.
- There are actually a number of other relative dating techniques, but 2 additional ones are: seriation & fluorine analysis.
  - Seriation orders artifacts into a series based on their similar attributes or the frequency of these attributes.
  - This is possible because the items of material culture tend to change in patterned ways over time. One well known example is: Stone -> Bronze -> Iron Age.
  - If you are curious visit this site for a demonstration of how this process works.
  - Fluorine analysis measures and compares the amounts of fluorine that bones have absorbed from groundwater during burial.
  - Used to expose the Piltdown hoax as it showed the skull was much older than the jaw.
  - If you are curious visit this site for a demonstration of how this process works.
Outcrop at Oludvai Gorge
• **Dating techniques based on radioactive decay**
  • These techniques provide absolute dates (also called chronometric dates).
  • This is a measure of the rate at which certain radioactive isotopes disintegrate.
    • **Radioactive isotopes** are unstable and over time will decay to form an isotopic variation of another element.
    • Confused? This site is great: [Radioactive dating game](#).
  • The rate at which a radioactive isotope decays is called its **half-life**.
  • The time period in which one-half of the amount of a radioactive isotope is converted chemically (into a daughter product).
  • For example, if the half life of a radioactive material is 100 years:
    • 1 half-life ((100 years) 50% of the original material remains ($\frac{1}{2}$).
    • 2 half-lives (200 years) 25% of the original material remains ($\frac{1}{2}$ of $\frac{1}{2}$).
    • 3 half-lives (300 years) 12.5% of the original material remains($\frac{1}{2}$ of $\frac{1}{2}$ of $\frac{1}{2}$).

• **Potassium-argon (K/Ar) dating** is the most important chronometric technique for hominins involves potassium-40 ($^{40}\text{K}$) which as a half-life of 1.25 billion years.
  • The decay of this radioactive material produces argon-40 ($^{40}\text{Ar}$) Based on the accumulation of argon-40 gas as a by-product of the radiometric decay of potassium-40 in **volcanic materials**.
  • Radioactive potassium has a half-life of 1.25 billion years and is used to date materials 1-5 mya, especially in East Africa.

• **Argon-argon ($^{40}\text{Ar}/^{39}\text{Ar}$) dating** is a variant of the potassium-argon method and is newer method.
  • It uses the ratio of argon-40 to argon-38 for dating **igneous and metamorphic rocks**.
  • It uses smaller samples, has less error, and is more precise a method.

• **Fission-track dating** is one of the most important techniques for cross-checking K/Ar dates.
  • Uranium-238 ($^{238}\text{U}$) decay occurs regularly by fission.
  • This decay leaves traces in certain geological materials and these microscopic tracks can be counted.
Radiocarbon Dating

Proportion of parent atoms remaining

Time units (1 unit = 1 half-life)

- = parent atoms  - = daughter atoms

Cosmic Radiation

Cosmic rays enter the earth's atmosphere and collide with an atom, creating an energetic neutron.

Neutron capture

When the neutron collides with a nitrogen atom, a nitrogen-14 (seven protons, seven neutrons) atom turns into a carbon-14 atom.

Carbon 14

Plants absorb carbon dioxide and incorporate carbon-14 through photosynthesis.

Animals and people eat plants and take in carbon-14.

Following death and burial, wood and bones lose C-14 as it changes to N-14 by beta decay.

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Age of Site or Specimen 2

- Dating techniques based on radioactive decay (continued)
  - Perhaps the most famous of the radiometric dating techniques is radiocarbon dating (also called carbon-14 dating).
    - Measures the $^{14}\text{C}/^{12}\text{C}$ ratio in samples of organic materials; after death $^{14}\text{C}$ decays back to nitrogen.
    - Used to measure materials ranging from 1-50,000 years old. Its half-life is 5,730 years.
  - Like all dates based on radioactive materials, the estimated date is expressed as a range (date +/- error).
  - Obsidian hydration results in the formation of a “rind” on the outside of the material, that can be dated.
  - Dendrochronology is a dating method based on the study of yearly growth rings in ancient wood.
    - Some can be cross-referenced to our own. For example:
      - Ancient Egyptian calendar.
      - Ancient Maya and Aztec calendars.
    - I suspect that you heard that 2012 was the end the world according to Mayan calendar. Good news. Newly discovered Mayan artifact suggests the Maya denoted no end of the world in 2012.
  - Luminescence dating based on radiation damage
    1. Thermoluminescence (TL) measures the accumulated radiation dose since the last heating or sunlight exposure of an object.
    2. Optically stimulated luminescence (OSL) uses laser light to release stored energy.
  - Paleomagnetic dating is a technique based on the constantly shifting nature of the earth’s magnetic pole.
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