MODULE 3: STONE TOOLS

The **Stone Tools** module is designed to introduce youth to how Indigenous people used stone tools. Stone tools have been made for millennia. Their production requires great knowledge about raw materials and how they can be fractured. This module will teach physics concepts.

Day 1: Watch flintknapping videos on YouTube or watch an expert flintknapper in-class demonstration. Explain the physics behind the process.

Day 2: Examine stone tool data (site locations, point types, AMS dates associated with the points).

Day 1:

PowerPoint on Artifacts (chipped stone)

Watch Flinknapping videos or watch someone flint knap in person.
Flintknapping With Dr Bruce Bradley (DVD or YouTube)

https://www.youtube.com/watch?v=4e_ribJLw30

https://www.youtube.com/watch?v=7oXJdAq9Tio

Lesson Plan: Stone Tools

Grade Level: 6-8

Objective: The goal of this lesson is to introduce stone tools, how they are made, and discuss the physics behind the process, including the attributes in the raw material necessary for producing a stone tool.

STEM: Physics, Geology

Materials: Videos of flintknapping demonstrations; or, if there is someone demonstrating knapping, safety goggles for all youth, raw material (of various types), knapping tools, drop cloth.

Time: 60 minutes

Overview: Stone was used as a raw material by almost all human cultures. For much of human history, artifacts made of stone are the only surviving artifact. Therefore, it is important for archaeologists to understand how stone tools were made and used.

Flint and chert were the most commonly knapped materials and are compact cryptocrystalline quartz. These materials are “silicates,” a family of cryptocrystalline quartzes that are good for knapping. Some other materials used are quartz, jasper, rhyolite, chalcedony, and obsidian (volcanic glass).

There are three major chert-bearing rock units in New York. Devonian limestones contain the chert-bearing Onondaga and Helderberg limestones; and Ordovician shales contain the chert-bearing Normanskill shale. The most extensive are the Onondaga and Normanskill formations. While all three rock units converge in the Hudson Valley region, Normanskill is confined geographically to the Hudson Valley and eastward while Onondaga Cherts outcrop in a broad band across southern New York from the western edge of the Hudson Valley to as far west as Buffalo. In the east the formation extends south into northern New Jersey, Pennsylvania, and Tennessee. In central and western New York, the Onondaga formation is the major chert-bearing unit. Helderberg cherts outcrop primarily west of the Hudson River along the Allegheny Plateau between the Normanskill and Onondaga formations. Normanskill, Helderberg, and Onondaga cherts were commonly used by precontact peoples in the Hudson drainage. In southern New York, Onondaga cherts are the most commonly encountered material at precontact sites. While primary quarry sources are not common, source areas have been identified for Onondaga chert in the Buffalo area, for Normanskill chert in the Coxsackie-Catskill area, and for Helderberg chert in eastern Green County, New York. Normanskill, Onondaga, and Helderberg cherts are commonly found as cobbles in secondary streams and gravel deposits.

People may have traveled many miles to find high quality stone for making tools. Stone that had the qualities necessary for tools (see below) was either gathered from stream beds or quarried from outcrops. These sources were returned to over time. Knowledge of where to find good raw materials for making stone tools was passed down orally through generations within a community. Precontact people learned to make stone tools from elders who were experts in tool production.

Physics behind Flinknapping
The stone must be brittle so that it will break easily and with a sharp edge. It has to have strength to maintain a sharp edge. It also has to be elastic to bend when the flake comes off and not shatter into fragments. It has to have no impurities or changes in texture to break equally well in any direction with no internal fracture planes that will predetermine how it will break. Where and how the material breaks can then be determined by the flintknapper and how he or she applies the force.

When the knapper hits the stone, the hammerstone transfers energy into the stone in the shape of a cone. This is like if a rock hits plate glass or a car windshield or if a pebble is dropped in a pond. A small hole is made and the energy passing through the glass (or raw material) forms a cone. Show a slow-motion video of a pebble or rain drops hitting water to watch the energy move through the water in concentric circles: https://www.youtube.com/watch?v=Pot-S4koghk

If the raw material is hit on its edge (and not the middle), the energy passes as a cone, but it does not go into the air, it comes back in and meets energy on other side of the cone and allows it to break and a flake is removed.

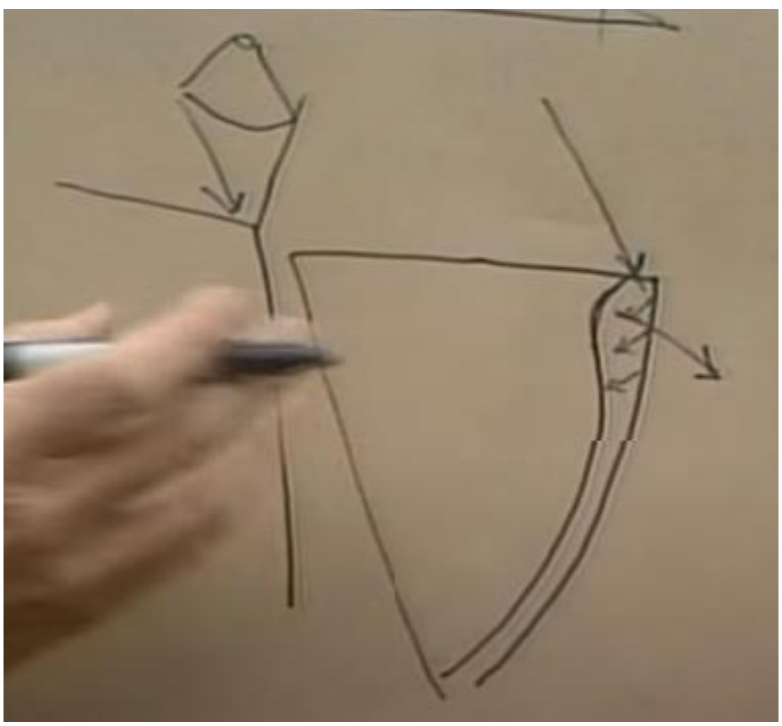


Image from *Flintknapping With Dr Bruce Bradley*.

Vocabulary: Flintknapping or knapping, flake, cryptocrystalline, silicates, hammerstone, quartz, jasper, rhyolite, chalcedony, obsidian

Procedure: Talk with the learners about what stone tools are and ask them how they think they were made. Have examples of some cryptocrystalline raw material and stone tools to show the youth. They will examine and compare different types of stone to see if they can tell any differences between the raw materials and to identify which materials would be most useful for making stone tools.

Watch the video or the knapper and demonstrate each principle of stone tool manufacture. If there is someone knapping, students must wear safety googles and maintain a safe distance from the knapper so stone material does not hit them during the manufacturing process. Students will handle tools used to make the stone tools and the stone tools themselves in various stages of production.

Give students flakes. These are the waste material from making a stone tool. However, their edges are sharp, and flakes were often used as tools themselves. Students can try cutting different materials (wood, leather, cloth, etc.) with the flakes and/or try cutting with flakes of different materials (jasper, chert, obsidian, etc.). Ask students what material was easiest to cut, and flakes made from what raw material were easiest to cut with. Students can also try removing bark from a stick with the flakes.

Review typology with the students and refer them back to Module 2. Have students create a typology for a set of projectile points (these can be 3D printed, images, or replicated spear or points and/or arrowheads). Youth can do two different typologies with the same points. Have them explain why they grouped the points the way they did each time. Show students a typology of NYS projectile points through time. Have them try to match their points with the points in the standard typology. For New York State, see William A. Ritchie's 1971 *New York Projectile Points: A Typology and Nomenclature*, Bulletin 384, New York State Museum, Albany, New York (available for download at the New York State Museum).

This next part of the lesson will lead into Module 4, **Hypotheses Testing**. Students will explore hypotheses about why projectile point styles changed through time and what they could have been used for (e.g., hunting mammals vs. spearing fish).

Ask students what they think are the differences between spear points, darts, and arrowheads and how they were used (e.g., spear thrower vs bow and arrow). Ask students what they think the different projectile points, or points, were used for (e.g., hunting mammals vs. spearing fish) and how we would know (comparing against intact hunting gear – wood, etc. preserved).

Students will use the measurements of particular point types from the typology module and compare them to known precontact darts, spears, and arrowheads to see if they can tell which points were used as darts, arrowheads, or spears based on the size and shape of the points (see metrics below).

We will also examine where the sites were located and on what landforms, the point types, and AMS dates associated with the point types. This will lead into the next part of the lesson in which students will begin to think about the general topics they want to learn more about for their research projects.

Start developing student research questions. Ask students what general topics they would like to research – hunting practices, how/where people obtained raw materials for stone tools, where sites of different periods were located, etc. These will be refined in the following module, Hypothesis Testing.

NOTE: This part of the lesson can be done in this module or wait until Module 4, Hypotheses Testing.

DATA for Hypotheses:
Darts vs Arrows

Measurements on known dart (n=40) and arrow points (n=130) from museum collections (ethnographic and archaeological contexts) in North and South America, as well as Australia are presented in the table below.

- Examine maximum length, point width, thickness, and neck width.
- These metrics may not adequately account for the range of variation in projectile points from the Eastern Woodlands.
- On average arrows are shorter, narrower, thinner, and have a smaller neck width than dart points. Arrow points are also generally lighter.

Group Statistics

	KnownPoint	N	Mean	Std. Deviation	Std. Error Mean
maximum point length	Arrow	130	30.584	8.3151	.7293
	Dart	40	51.507	13.8597	2.1914
maximum point width	Arrow	130	14.444	3.3960	.2978
	Dart	40	23.048	4.4519	.7039
projectile point thickness	Arrow	130	3.902	1.1075	.0971
	Dart	40	4.963	1.0032	.1586
minimum neck width	Arrow	130	9.825	2.5692	.2253
	Dart	40	15.132	3.2588	.5153

Outcomes: By the end of the lesson, students will be able to answer the following:

- What techniques are used to make stone tools?;
- What materials are used as tools to make stone tools?;
- From what types of stone are the stone tools made?;
- Where are they found in NY?
- What materials would survive from the stone tool manufacturing process?;
- What would a stone tool manufacturing site look like archaeologically?

Day 2: Introduce radiometric dates associated with sites that produced the same styles of projectiles examined in Day 1, and help learners develop hypotheses about why these styles changed through time and what they could have been used for (e.g., hunting mammals vs. spearing fish).

Lesson Plan: Dating Methods

Grade Level: 6-8

Objective: The goal of this lesson is to introduce youth to how archaeologists date an archaeological site or know how old an artifact is.

STEM: Physics

Materials: PowerPoint.

Time: 15 minutes

Overview: The first thing archaeologists want to know about a site is how old it is. There are several methods that can be used. Some allow the site to be tied to a calendar date (some more precisely than others; chronometric dating), while other methods allow archeologists to tell if one site is older or younger than another (relative dating). While there are many methods for dating sites depending on where they are found in the world, what is found, or how old the site is, we will focus on the methods most commonly employed for dating the precontact period in Eastern North America.

Vocabulary: Chronology, chronometric dating, relative dating, stratigraphy, radiocarbon dating

Procedure: Ask students how they tell time (what tools and units do you use?; e.g., minutes, hours, days, months = clocks, calendars). How do archaeologists tell how old a site or artifact is? Discuss the difference between chronometric and relative dating. Present the most common methods of dating used by archaeologists in your area of the world. For the precontact period in Eastern North America, we will focus on stratigraphy and radiocarbon dating.

How do archaeologists tell time?

Chronology = sequence of events in time

1. Relative Dating (up until 1950s)

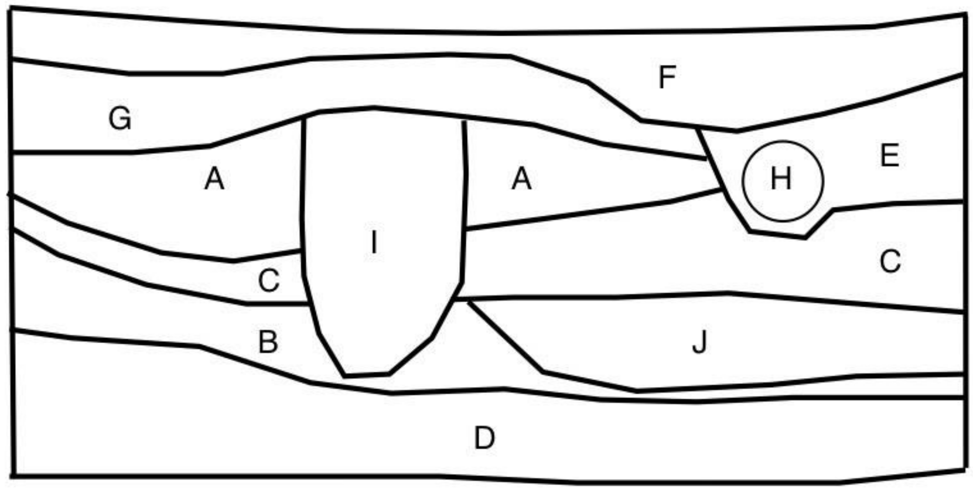
Not tied to calendar, no specific dates; only older than or younger than relationships; or the same age

Example: Stratigraphy

Stratigraphy (undisturbed):

Sediments deposited in layers over time

** Show students a unit profile photo or a drawing. Use a drawing of a profile with stratigraphy, artifacts, and features. Ask students what layers or features are older/younger.



2. Chronometric or Absolute:

Dating methods that give results tied to modern calendar
Give results as years of age from the present
Still with varying degrees of uncertainty; plus/minus range ($\pm$)
Nomenclature:

AD/BC: relation to the birth date of Jesus Christ; BP: Before Present = years before 1950; BCE: Before Christian/Common Era

**Remind students of our lesson last week on the precontact period and that the dates for the periods were labeled as BC and AD.

C-14: Developed by W. Libby (Chemist) 1949

Based on decay of ^{14}C - radioactive isotope of Carbon
^{14}C half-life = 5,730 years, decay emits beta particles
All living things absorb ^{14}C until death
After death, ^{14}C begins to decay at predictable rate
Measuring rate of decay infers amount of time since death based on ^{14}C half-life

That is, all living things contain carbon. When the organism dies, it decays a little each year and releases that carbon. Scientists can predict how much carbon is lost each year after death, but it is not exact. They can estimate the age within a certain number of years, hence the +/- (a time range).

One way to demonstrate half like is to have students divide a block of clay (approximately the same size and weight) in half, then divide one half in half and so on and so on. At some point, it gets too small to cut. This happens in dating – eventually there is not enough to measure. When the clay is at this point, have students measure or weigh what is left. Ask them if each person's is the same size or weighs the same. If they differ, tell them that radiocarbon dating is not precise, there is always a date range (just like their remaining clay "ranges" in size/weight). Alternatively, have students cut their block a set number of times, measure, and compare.

Date= probability that true date falls within range, based on standard deviation (e.g., 2500BP $\pm$50 years)

1 sigma (1 standard deviation) = 66% (2450-2550 BP);
2 sigma = 95% (2400-2600 BP): Doubling sigma halves precision (increases $\pm$ range)

Confidence interval: This proposes a range of plausible values for an unknown parameter (for example, the mean). The interval has an associated **confidence level** that the true parameter is in the proposed range. The confidence level is chosen by the investigator. For a given estimation in a given sample, using a higher confidence level (e.g., 2 sigma) generates a wider (i.e., less precise) confidence interval.

Most often used on charcoal/carbonized plants.